Established by BENJAMIN SILLIMAN in 1818.

THE

AMERICAN JOURNAL OF SCIENCE.

EDITOR: EDWARD S. DANA.

ASSOCIATE EDITORS

PROFESSORS GEO. L. GOODALE, JOHN TROWBRIDGE, H. P. BOWDITCH AND W. G. FARLOW, OF CAMBRIDGE,

PROFESSORS O. C. MARSH, A. E. VERRILL AND H. S. WILLIAMS, OF NEW HAVEN,

PROFESSOR GEORGE F. BARKER, OF PHILADELPHIA,
PROFESSOR H. A. ROWLAND, OF BALTIMORE,
MR. J. S. DILLER, OF WASHINGTON.

FOURTH SERIES.

VOL. VI—[WHOLE NUMBER, CLVI.]

No. 36.—DECEMBER, 1898.

NEW HAVEN, CONNECTICUT.

1898.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 125 TEMPLE STREET.

Published monthly. Six dollars per year (postage prepaid). $6.40 to foreign subscribers of countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks.

CHRISTMAS.

A few hints as to some acceptable presents selected from the largest stock of minerals in the world. They are for young people—or old either—for no one entirely lacks interest in nature's works.

A pretty collection will be sure to awaken a love of nature-study, and to one already the possessor of a collection, a few beautiful specimens will be a welcome addition. In our systematic collections, the specimens are typical and well selected; many are quite showy and attractive. The two larger sizes are labeled with complete printed label, and numbered to correspond to list; the fragments are numbered only. In the polished Oak Compartment Cabinets, they present an especially neat appearance. Lists sent free.

No. 15, Dana Student's Collection, 180 specimens averaging 2½ by 2 in., $25.00. Drawer Cabinet and trays, $8.75 extra. Total weight, packed, about 125 lbs.

No. 16. Same, 1¼ by 1¼ in., $10.00. Compartment Cabinet, $2.40 extra. Wt. packed, 33 lbs.

No. 17. Same; fragments averaging ¾ in. diam. in Cabinet, $6.60. Wt. packed, 7 lbs.

No. 21. Dana Pupil's Collection. 120 spec., 1¼ by 1¼ in., $6.00. Cabinet, $1.60 extra. Wt. packed, 19 lbs.

No. 22. Same; fragments, ¾ in., in cabinet, $3.80. Wt. 4½ lbs.

No. 24. Prospector's Collection. For practical use, 120 spec., 1¼ by 1¼ in., $7.00. Cabinet, $1.60 extra. Wt. 19 lbs.

No. 66. Abridged Collection. 60 spec., 1¼ by 1¼ in., $3.00. Cabinet, 80c. extra. Wt. 9 lbs.

No. 67. Same, fragments, ¾ in., in cabinet, $1.90; postage, 35c.

No. 72. Agassiz Collection. 25 fragments, ¾ in., in cabinet, 75c.; postage, 18c.

No. 80. Crystal Collection. 25 in cabinet, $3.00; postage, 15c.

No. 86. Collection of 25 Microscopic Minerals in cabinet, $4.00; postage, 15c.

Following are selected bright and showy crystallizations in shapely groups of 2½ to 5 in. diameter. As odd paperweights or to adorn the shelf of the collector they are equally desirable. Postage, 15c. to 40c.

Rubellite, Pink Tourmaline. Slender crystals in lavender rock, 15c. to 50c.
Quartz, Rock Crystal. Colorless hexagonal crystals, 25c. to $2.00.
Fluorite, "Fluor Spar." Purple cubic crystals, 25c. to $1.00.
Hematite. Jet black, often iridescent crystals, 25c. to $3.00.
Sulphur. Gorgeous yellow crystals, 25c. to $1.50.
Endlichite. Small lustrous crystals on dark gangue, 75c. to $3.00.
Wulfenite. Orange, red crystals, 50c. to $3.00.

Also the following in polished pieces:

Opalized Wood. $1.00 to $3.00 (unpolished, 25c. to $1.00).
Agate, Moss or Banded. 25c. to $3.00.
Verde Antique. 50c. to $1.00.

Precious Opals. Choice assortment of finest quality stones just imported by us direct from Australia. Very low prices, $1.00 to $8.00 per carat, ⅛ to 2 carats each.

Dr. A. E. FOOTE,

WARREN M. FOOTE, Manager.

BOOKS AND MINERALS,

1317 Arch Street, Philadelphia, Pa., U. S. A.

Established 1876.

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XLIV.—*Another Episode in the History of Niagara Falls;* by J. W. SPENCER.

[Read before American Association for the Advancement of Science, August, 1898.]

CONTENTS:

Summary of the Changing Physics of the River.
Revision of the Episodes of Niagara River.
The Newly-discovered Episode—the Niagara Strand.
The Modern Episode.
The Rise of the Ontario Waters.
Explanation of the Narrows of the Gorge at the Whirlpool Rapids.

Summary of the Changing Physics of the River.

FOUR years ago, a paper was presented by the writer to the American Association for the Advancement of Science,* computing, for the first time, the age of the Falls, as based upon the changing episodes of the river. The data upon which the computations were made embraced not only the measurement of the modern rate of the recession of the Falls, but also the discoveries: (1) that the Niagara River did not formerly drain the Algonquin (Superior-Michigan-Huron) basin (which then emptied towards the northeast)†; (2) that the river for a long

* "Duration of Niagara Falls," by J. W. Spencer, this Journal, vol. xlviii, pp. 455–472, 1894.

† Mr. F. B. Taylor has stated that the "original hypothesis" of "a northern way of discharge of the upper lakes" was first suggested by Mr. G. K. Gilbert in 1886 (Bull. Geol. Soc. Am., vol. ix, p. 80, 1898). But it is manifest that Mr. Taylor is laboring under a misapprehension. The discovery of the evidence and the announcement of the hypothesis that the drainage of the uppermost three lakes was diverted from the Niagara River, by the discharge of their waters towards the northeast, was first communicated by the present writer to the meet-

time descended only 200 feet in place of 326 feet, as to-day; (3) that Foster's flats recorded the amount of recession of the Falls during the earlier stages, when the Erie waters alone drained through Lake Erie, and cascaded over a diminished fall; (4) that when the Falls had receded to Foster's flats, all the drainage of the upper lakes was turned into Niagara River; (5) that again the descent of the river was increased to 420 feet (as first shown by Prof. G. K. Gilbert), which increase gave rise to a succession of cascades, after which the height was supposed to have been directly reduced to the present level. The most important and continuous of these cascades was that over the Medina sandstone, still represented by rapids; and it may be most properly named the Gilbert Falls.

These changing conditions in the physics of the river necessarily greatly modified the rate of recession of the Falls, and from their considerations, a new determination of their age became necessary. These calculations were only a stepping stone towards ascertaining the age of the Falls, and each addition to our knowledge of the various phases of the river will enable us to approach a more accurate computation of the duration of the Falls. There was also brought to light for the first time a means of determining the rate of the upward movement of the earth's crust, and the evidence of the extinction of the Falls by the diversion of the waters of all the upper lakes into the Mississippi by way of Chicago.

However, all the physics of the river were not satisfactorily explained. Thus the section of the cañon, about 4,300 feet* long, at the Whirlpool Rapids, is the narrowest and shallowest part of the gorge, not explicable by a changing character of the rock. Even the provisional explanation of the writer was not satisfactory to himself, and accordingly another was offered by Mr. F. B. Taylor, which will be noted later. Subsequently, Prof. Gilbert estimated various depths of the river channel,†

ing of the American Association for the Advancement of Science in 1888, of which an abstract appeared in the Proceedings of the Society for that year.

That which Mr. Gilbert had written was as follows: "The rate" (of recession of the Falls) "may also have been influenced . . . by variation in the amount of its volume" (i. e. of the Niagara River) "due to change of climate or catchment basin. The catchment basin was formerly extended by including parts of the area of the ice sheet. It may have been abridged by the partial diversion of the Laurentian drainage to other courses" (Proc. A. A. A. Sc., vol. xxxv, p. 223, 1886). This is the entire statement, implying the possibility of changes of outlet in any direction being a subject for consideration, and does not advance the discovery or hypothesis as stated by Mr. Taylor, although it announces the hypothesis of an increased discharge from glacial waters.

* Originally only a length of 4,000 feet was taken.

† See American Geologist, vol. xviii, pp. 223, 1896. The maximum depth of the river had been found by soundings to reach 189 feet in the basin just below the modern falls; and 96 feet in depth immediately outside the end of the gorge. Mr. Gilbert estimated the depth of the whirlpool rapids at 35 feet; of the whirlpool, 150 feet; of the channel at outlet of whirlpool at 50 feet; of the basin

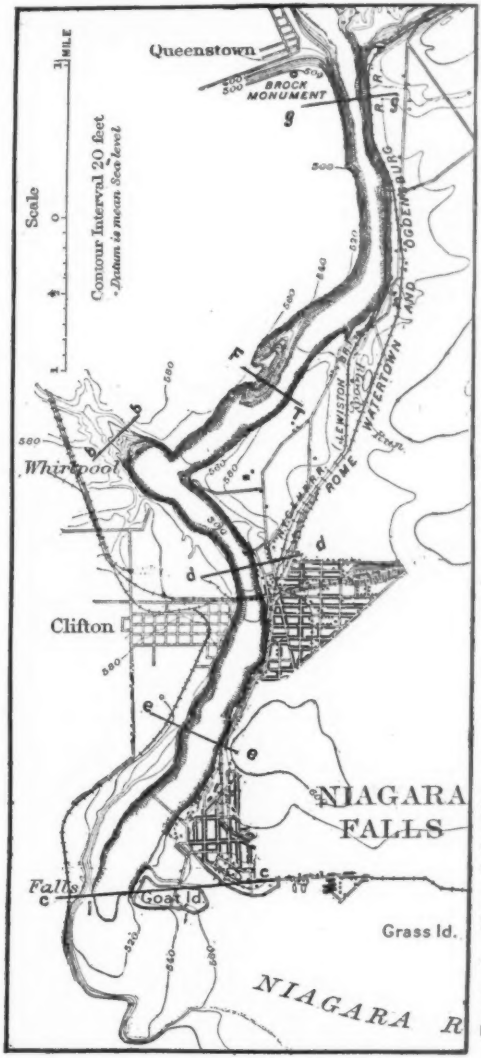


FIGURE 1. Map of the Niagara gorge, showing its variable width. F, location of Foster's flats. The thin (560 feet) contour line on each side of the section above Foster's flats has been found to nearly coincide with the banks of the river before the waters sunk within the gorge, thus showing that the breadth of the river was not diminished at the Narrows until after the excavation of the gorge through Johnson's ridge. (*ee*) crossing the course of the river between the upper bridge and the town of Clifton.

where actual surveys could not be effected. Recognizing that the peculiar feature of the gorge at the Whirlpool Rapids

immediately above Foster's flats at 100 feet, while the rapids in front of Foster's flats are reduced to 35 feet, and then the channel increases to 70 feet before passing out of the cañon section.

recorded some change in the history of the river, the writer set to work to enquire why the channel appeared to be scarcely more than about 35 feet deep, while above it, nearer the Falls, its depth reaches to from 160 to 189 feet. This investigation has led to the discovery of an important episode in the history of the Falls, namely, that after the river reached its maximum descent of 420 feet, the surface of Lake Ontario was gradually raised 75 feet above the present level, and the waters stood in the Niagara gorge so as to reduce the descent of the river to 250 feet, before the final lowering of the Ontario waters to a level of 326 feet beneath those of Lake Erie. This discovery will be found to explain the greater shallowness of the channel at the Whirlpool Rapids than below or above.

Revision of the Episodes of Niagara River.

As previously described,* the first episode of the river was characterized by a cascade comparable in size to the American Falls, draining the Erie basin alone (whose discharge is only between one-fourth and one-sixth† that of the basins of the four upper lakes), and descending 200 feet into the lower lake, then at the level of the Iroquois beach. This condition prevailed until the cataract had receded about 9,000 feet‡ from the mouth of the gorge§ (see figure 1).

The commencement of the second episode was marked by the increase in the volume of the water, owing to the drainage of all the upper lakes being turned into the Niagara. This caused the river to broaden its channel so that the cañon, along the section of Foster's flats (F, fig. 1) and for some distance above, is much wider than below. But the height of the Falls was not increased until after they had receded a further distance of 6,300 feet,‖ when Foster's flats had been passed. That the height was not increased is shown by the fact that the flats represent the floor of the channel at that time,

* See Duration of Niagara Falls.

† The discharge was measured by the Corps of Engineers, U. S. A. Report for 1869, p. 582. In the early part of the season, when the summer drainage was coming from the upper lakes, the discharge of the Erie basin was 16·3 per cent that of all the four lakes. Later in the season the discharge of Erie increased to 28·9 per cent. The mean discharge was 22·5 per cent. Consequently it would be better to accept this proportion in place of approximately one-fourth.

‡ Originally taken to the foot of Foster's flats, 11,000 feet; but now to only where the gorge widens, near the Catholic College, for it appears that the lower part of the flats have been denuded away.

§ This section of the modern river has reoccupied the extension of the buried shallow preglacial depression or valley of Bloody Run, and this in part explains the change of course and the narrowness of this lower section.

‖ The best development of Foster's flats is 3,000 feet long, which measurement was originally used, but the full length is about 3,700 feet, to which length is now added a section of 2,600 feet of the cañon below, with a corresponding breadth.

although this floor is now from 35 to 50 feet above the level of Lake Ontario; with the remains of a terrace considerably higher. The rugged features of the upper part of the flats indicate a transition stage. Had the descent of the river been increased to the maximum at this time, the excavating power of the Falls should have cut its channel deeply in the rock beneath the floor, of which Foster's flats is a remnant. The correctness of this conclusion is shown by the deeper (see section, fig. 2) and wider channel above this section. The great power of excavation during the full height of the Falls is also illustrated just below the present cataract, where the thick bed of hard Medina sandstone, the same as at Foster's flats, has been more than penetrated by the impact of the water, although this hard bed is far beneath the surface of the river. The upper end of the flats (see F, fig. 1) marks the closing of the episodes of the first inferior descent of the river.

The excavation of the deep basin between the head of Foster's flats (see fig. 2) and the whirlpool shows the amount of work performed by the Falls during the next episode, when the descent of the full volume of the river was increased from 200 to 420 feet; but of the increased descent probably quite 170 feet* was situated in the lower part of the gorge and its extension to the retreating shore line of Lake Ontario, when the channel below the end of the gorge was excavated to a depth of a hundred feet below the present surface of the lake. It was the Medina sandstone, now exposed, which gave rise to a distinct cascade, before mentioned, occurring two and a half miles below the front of the main falls. This lower cataract, with an interrupted history, has not yet completed its work, although it has cut the modern secondary cañon through Foster's flats, having a width reduced to only 380 feet† with vertical walls from 40 to 50 feet high. Here the river is estimated at 35 feet deep, although it greatly increases in depth below the flats. This portion of the river is still characterized by heavy rapids.

While the main cataract was descending over Niagara limestone, just above Foster's flats, and the lower or Gilbert Falls cascading nearer the mouth of the gorge (see section, fig. 2), there seems to have been an intermediate fall from the harder beds of the Clifton rocks; but as these do not give rise to a separate cataract to-day, there does not appear any reason to suppose that the intermediate cascade continued

* The floor of Foster's flats was 130 feet above the lake level as established when the Niagara River descended 420 feet, with the estimated depth of water in this portion of the cañon reaching 40 feet above it, or the descent of the lower fall and rapids amounted to 170 feet.

† Surveyed by an engineer for Mr. George Holley.

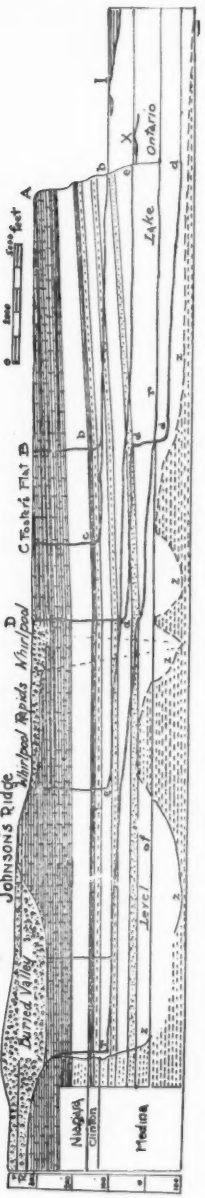


FIGURE 2. LONGITUDINAL SECTION OF NIAGARA GORGE, showing the floor of the channel on (shaded) Medina shale, and the theoretical position of the Falls and profile of the river at the end of each episode—(1) *Bbb*, (2) *Ccb*, (3) *Dddd*, (4) *Eee*, *Rrr*. F, site of modern falls; I, position of the Iroquois Beach; X, position of the Niagara Beach; *zzz*, the three deep basins. Foster's flats are located on the (dotted) band of Medina sandstone at 35–50 feet above the lake. A similar remnant occurs at outlet of whirlpool. Johnson's ridge is a rocky barrier in front of the broad preglacial valley.

long to be an important feature, although remnants of terraces corresponding to its height are traceable at Foster's flats, at the mouth of the whirlpool, and perhaps a few hundred feet above this point, near the foot of the Whirlpool Rapids upon the eastern side.

This epoch of maximum volume and descent appears to have been of short duration, as the deep channel above Foster's flats is only 3,200 feet in length, and is limited by the barrier at the outlet of the whirlpool (fig. 2), which is a later remnant of a river floor similar to that of the flats below. The same hard Medina ledges are exposed as far as the foot of the Whirlpool Rapids. The deeper cauldron of the whirlpool behind its contracted outlet occurs only as an incident in the excavation of the gorge, for, in part, it was the site of a short fragment of an ancient buried channel, and it is not a record of the changing episodes of the modern Niagara. The occurrence of the rocky ledge, at the mouth of the whirlpool, indicated that the maximum descent of the river was reduced when the Falls reached this point. The dissection of this ledge by a channel, only 400 feet in width and 50 feet in depth, is the work of the modern restoration of the lowest cataract, which was interrupted as will be explained later.

The Newly-discovered Episode—the Niagara Strand.

The closing part of this last episode, and the next, during which the Falls receded to a point above the Narrows (fig. 2) of the Whirlpool Rapids has proved the most difficult of explanation. The writer provisionally adopted* a hypothesis by which the maximum height of the Falls was continued throughout this section. But the recent investigation shows that during this time the descent of the river was reduced from 420 to 250 feet, before it was increased to the present amount of 326 feet. Consequently, in the earlier writings upon the history of the Falls, this important episode, and its effect upon the Falls, were unknown.

Below Foster's flats, the sloping sides of the gorge are covered with talus, while the section passing the flats is that of a newly formed cañon with vertical walls, except at the foot (showing a transition stage). Opposite the lower end of the flats, there is a delta deposit of river stones, some of which are more or less subangular, forming a sort of terrace within the cañon, rising to a height of 70–75 feet. Its occurrence shows first the excavation of the gorge, and then the rise of the waters in it to the named height, so as to have allowed the accumulation of the deposit. The evidence of this rise of the river is further demonstrated by the occurrence of terraces immediately below the end of the gorge, having a height of 50–55 feet, on which there is a beach-like gravel ridge at an elevation of 70–75 feet above Lake Ontario. This terrace with its surmounting ridge is here named the Niagara Strand. The further sinking of the water is shown in the terraces at about 35 feet, and at 5–10 feet. The rising of Lake Ontario to a height of 75 feet would back the surface of the river to not merely the whirlpool, but had the cañon been excavated, it would have extended the lake level to about the point of the inclined railway (opposite the middle of Whirlpool Rapids). This backing of the waters would naturally protect the floor from erosion, and would explain the shallowness of the section of the Whirlpool Rapids. The amount of work performed by the Falls during this episode of reduced descent of the river is represented by the excavation of the cañon for a distance of 6,800 feet,† to a point just above the railway bridges, figure 2 (less that portion of the rock which had been removed from the valley in preglacial times). The narrowness of the gorge at the Whirlpool Rapids will be considered later.

* See Duration of Niagara Falls, cited before.

† Of this distance, 2500 feet is the portion of the section between the Medina sandstone barrier at the outlet of the whirlpool and the foot of the rapids above, while through the Narrows the length is 4300 feet.

The Modern Episode.

The last episode, or that of the present day, is characterized by the waters sinking again, so that the descent of the river has been increased, and now amounts to 326 feet. But this change was not continuous, for the descent was 350 feet or somewhat more, while the falls were receding through Johnson ridge (see fig. 2), back of which there was a preglacial valley 90 feet deep, that upon being reached by the falls, caused the waters to be lowered to the present amount. The dissected rocky ridge is 4,800 feet across before reaching the buried valley behind it (at a point near the upper bridge). Here the river channel has a depth of 160 feet, although above the shallow Whirlpool Rapids. Since passing this Johnson's ridge the Falls, with their height as now seen, has receded a further distance of 6,400 feet—thus completing a section of 11,200 feet during the modern episode of two stages. The mean recession of the Falls is now $4\frac{1}{6}$ feet a year.

With the last increase in the descent of the river, the lowest or Gilbert cascade was reëstablished, of which remnants occur in the rapids at Foster's flats and at the outlet of the whirlpool.* The more shallow channel of the Narrows has also given rise to an intermediate cascade in the form of the Whirlpool Rapids, with the descent of about 60 feet.

The Rise of the Ontario Waters.

Further evidence of the backing of the waters in the Ontario basin may be seen in the former lagoon, behind Burlington heights, at the head of Lake Ontario, where the gravel beds of the Iroquois Beach epoch have been eroded and subsequently covered by silt. This deposit of from four to eight feet in thickness was accumulated in the quiet waters of a protected bay when Lake Ontario stood at about 70 feet above its present level, at which height it forms a conspicuous terrace and plain.

The Niagara Strand is well marked in the small embayment behind the Iroquois Beach at the outlet of the Niagara gorge. Farther down the river, it is well shown as a superficial deposit of waterworn pebbles and sand at a height of

*This interpretation of the modern nature of the cañon in front of Foster's flats seems apparently to escape Mr. Taylor's observation, as he quotes Prof. Gilbert: "The shoals at Wintergreen flats (i. e. those at Foster's flats) and the Whirlpool Rapids are correlated with the epoch when the discharge of the upper lakes by way of the Trent and Mattawa Valleys left the Niagara River and Falls too small and weak for deep excavation" (p. 80 of Mr. Taylor's paper to be cited). As the modern cañon past Foster's flats is all that is being excavated by the full volume of the Niagara River, the extraordinary appeal for a cause of its smallness need not have been made to this evidently modern section had the rise of waters in the gorge been known, followed by the reëstablishment of the Gilbert Falls over the Medina sandstone, which falls in the form of the rapids are still continuing.

about 70 feet. These gravels are very thickly strewn upon the almost flat surface down to an altitude of about 50 feet above the lake, surmounted by low ridgelets. It extends as a zone eastward of the river and marks the gradual lowering of the lake, which at the mouth of the gorge is more strongly marked by the terrace (at 50 feet) and capping ridge of gravel (seen also at the site of the Church at Queenstown. It is seen at the St. Catherine's to the west. The Niagara Strand, east of the Irondequoit Bay, is represented by a sand terrace faintly separable from other delta deposits. West of Great Sodus Bay, it forms a strong terrace at about 40–50 feet above the lake, surmounted in places by a sand beach rising to 65–70 feet. At other points it is seen as the terrace plains of valleys.

The cause of the temporary rise of the waters of Lake Ontario is easy of explanation. From the excessive tilting of the earth's crust at the outlet of Lake Ontario, the water in the Niagara district rose (in so far as it affected the physics of the river) from a level 80 feet below that of the present day to about 75 feet higher than now. The subsequent withdrawal of the water was brought about by the St. Lawrence River cutting a deeper channel for itself, largely out of drift deposits, thus lowering the water of the lake to its present level. These conclusions are based upon the following evidence. The present channel of the St. Lawrence ordinarily varies from 60 to 80 feet, but there are deeper holes, one of which reaches a depth of 228 feet. In passing through the islands below the outlet of Lake Ontario, one is constantly observing fragments (sometimes of limestone rock) of the former bed of the river, now raised from 5 to 10 feet above its surface. But the first rocky barrier now crossed by the river is at the Galops Rapids, 75 miles below the outlet of the lake. The narrowest part of the river is here half a mile wide, with a depth, even on the rapids, of from 30 to 45 feet. Before the removal of the barrier by the river dissecting it, the water stood at from 100 to 140 feet above the present level. Many remaining points on the islands in the river rise to about a hundred feet or more. Upon the southern side of the St. Lawrence as at Cape Vincent, there is a series of terraces at 30, 40–45, 50–60, 80, and 90–100 feet within a mile and quarter of the shore. The northern shore rises to 100 feet, close to the river. The country at this height, or at slightly greater altitude, forms plains often miles in width, and extended across the channel of the St. Lawrence River, which is a groove excavated out of it. The material removed from the channel was largely drift, but not entirely. The plains characterizing the surface of the barrier to the Ontario basin are often in the form of terraces, bounded by abrupt steps (old shore lines or banks) rising to those of higher levels—notably at 90, 115, and 140 feet above

the lake. The succession of plains can be traced for a long distance down the St. Lawrence, so that one may conclude that there has been comparatively little warping or unequal deformation of the region, since the river began to deepen its channel. Thus it would seem that the dissected barrier had a height between 100 and 140 feet, and that the subsequent uplift of the region has been only about 25 feet more than at the mouth of the Niagara gorge. Thus the features of Lake Ontario confirm the hypothesis of the recent rising of the waters in the Niagara gorge, which has been adopted to interpret one of the important episodes in the history of Niagara River.

Explanation of the Narrows of the Gorge at the Whirlpool Rapids.

The most important feature in the history of the river that has remained unexplained is the narrowing of the cañon along the section of the Whirlpool Rapids. Mr. F. B. Taylor* has accounted for both the narrowness and the shallowness of the section somewhat as follows. He says that one of the principal hypotheses for explaining the section of the gorge at the Whirlpool Rapids is that "the whole gorge, excepting always the whirlpool basin, has been made by the modern or postglacial river Niagara, and that the magnitude of the gorge in the different sections is due to the variation of volume." He says that this seems to be the simpler of the hypotheses and proceeds *a priori* to support his proposition by a lengthy brochure entitled "Origin of the Gorge of the Whirlpool Rapids at Niagara." According to his supposition, the waters of the Huron basin, hitherto retained by an ice dam to the northeast, were now withdrawn from the Niagara discharge while the falls were passing the whirlpool section, thus reducing its volume to one-ninth the present amount. Here it should be noted that by actual measurement, the drainage is between $\frac{1}{8}$ and $\frac{1}{4}$ (at different periods of the season of measurement). Until there is a more perfect determination, these are the only figures that we have to go by. Not only has he reduced the discharge of the Niagara to half as great as indicated by ascertained data, but he neglects to take into account the evidence of the buried channel at this point, which in part still remains intact upon the sides of the chasm, and which the modern river has taken possession of. Such a depression is only characteristic of this section of the Whirlpool Rapids, for just at its foot the rocky walls are higher than those along the mid section. Mr. Taylor assumes that the preglacial gorge of the whirlpool ended abruptly, in an amphitheater, like modern cañons, and not by transition slopes (which everywhere mark the features of the preglacial erosion) from the buried

* Bull. Geol. Soc. Am., vol. xix, pp. 59–84, 1898.

valley above the cauldron. Indeed the sloping features are preserved in the extension of the whirlpool valley, where not remodified by the modern Niagara, showing that we have not far to go for evidence.

The diminution of the volume of the river would not explain the shallowness of the channel at the Whirlpool Rapids. We find to-day many small streams near the Niagara district which are excavating their cañons directly through the lower hard layers of the same strata as in the gorge, showing that the streams of insignificant volume are penetrating the rocks to the base-level of erosion as well as those of great magnitude. Consequently, Mr. Taylor's hypothesis does not satisfy the shallowness of the Whirlpool Rapids, which demands a reduction in the height of the falls, such as has been found to have obtained.

The other question which the hypothesis of the glacial dam was hoped to explain was the narrowness of the section of the Whirlpool Rapids. If the waters of the Huron basin had been completely diverted from the Niagara drainage at this time, the narrowing but not shallowing of the cañon might be partly explained. But of it there appears no evidence. From the preservation of the river banks outside of the narrows of the gorge, the width of the channel is seen to have been maintained at the full breadth and depth. This statement may be seen somewhat illustrated in fig. 1 (page 441), below which there is an explanatory note. The constriction applies to the gorge alone. This section differed materially from the country above and below it, as here the Niagara River came to occupy a shallow and small preglacial valley, which was filled by drift to the depth of forty or fifty feet, as seen in the banks of the deserted channel of the river beyond the edge of the chasm. The depth of the depression was greater in its center, and the river took possession of the deeper portion, and upon the removal of the drift, sunk within the narrow gorge. This is found to have been the case, for at the place where Mr. Taylor describes the pause of the falls, at the foot of the present Whirlpool Rapids, the surface rocky floor of the old valley at that point is 20 feet higher than in the deeper remains of the channel exposed above it; thus showing that there was a deeper medial channel subsequently developed into the narrow chasms. This shallow-buried valley began in Johnson's ridge, just above the railway bridges (see figs. 1 and 2), and extended to the whirlpool, whose cauldron is only the deeper extension of the same ancient channel. Accordingly it is readily seen that the length of the section of the Narrows and that of the preglacial depression coincide.

When the Falls had retreated as far as the whirlpool, and had removed the rocky barrier at its outlet, the buried channel

would have been quickly reëxcavated by the current easily removing the drift filling. With the channel being thus deepened so rapidly, in loose material, it would cause a concentration of the current within a narrow gorge, and materially augment the mechanical effects upon the floor of the cañon —thus deepening without broadening the chasm. Indeed, is not this feature of the contraction of the cañon perfectly developed at the outlet of the whirlpool, where the whole volume of drainage of all the upper lakes, by Niagara River, rushes, as out of a waste weir, through a channel only 400 feet wide, with an estimated depth of 50 feet? Thus there seems no reason to suppose that the volume of the river was, during this episode, reduced to one-fourth or one-fifth of the present amount,—as would have been the case with Mr. Taylor's hypothesis, especially as the work of the Falls would have been greatly diminished by the reduced descent of its waters (as already described on page 445).

A partial reduction of the volume of the water, at this time, was more than probable, but from another cause than that here discussed. In the "Duration of Niagara Falls,"* it was shown that the Johnson ridge caused the waters of the Erie basin to rise to the point of discharging a portion of the waters of the upper lakes into the Mississippi, by way of a new outlet near Chicago. But the falls dissected Johnson ridge before there was an extensive drainage of the Niagara waters to the Mississippi; whereupon there was a lowering of the upper lakes below the Chicago overflow. At this distant day, it is difficult to estimate the exact amount of such discharge which may have been greater than at first supposed. The terraces or shore-lines in the St. Clair outlet of Lake Huron, at an elevation of fifteen or twenty-five feet above the level of Lake Erie, apparently correspond with the level of the Erie waters, as they were being raised by the Johnson ridge before it was dissected by Niagara Falls. Thus the deserted shore-lines of the lakes support the evidence of the partial drainage, at this time, of the upper lakes into the Mississippi.

The physical conditions as now described account more fully for the narrows of the gorge than any previous explanation, as the cause of its shallowness seems to have been made clear. This solution of a condition previously overlooked may possibly be found entirely sufficient, and it has an advantage of being in full accord with mechanical forces which we see at work in Niagara to-day. The new discoveries in the history of Niagara River, which have here brought about a revision of the episodes, will somewhat alter the estimate of the age of the Falls from 32,000 years, but whatever figures result they will doubtless approach more nearly the true age of the Falls.

* Cited before.

ART. XLV.—*On an Apparatus for Measuring very High Pressures;* by A. DEFOREST PALMER, JR.

SOME time ago, while I was investigating the relation between the electrical resistance and the pressure of pure mercury, Prof. Barus remarked that the results might be used by exterpolation in the calculation of very high pressures, and suggested that I undertake the construction of an apparatus to utilize this principle and determine the limit of pressure obtainable with a tinned screw. After several disappointing preliminary trials the method described below was finally adopted and found to give very satisfactory results.

1.

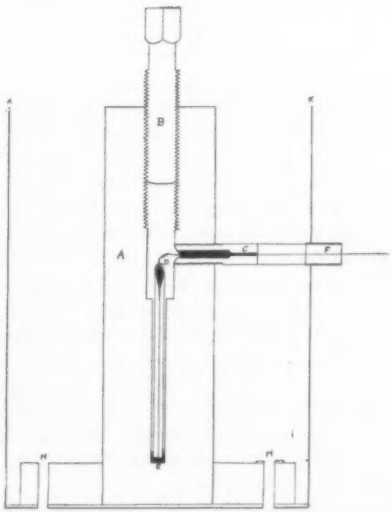
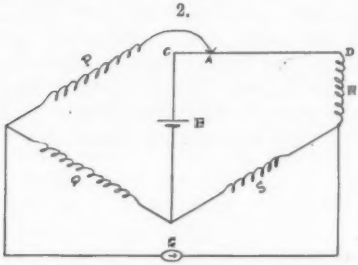


Figure 1 is a sectional diagram of the piezometer. A is a Bessemer steel cylinder, two inches in diameter and seven inches long, firmly keyed to a cast-iron collar having holes H H for anchor bolts. D is a capillary glass tube, about one-tenth millimeter in internal diameter and eight centimeters long, filled with pure mercury electrically connected with A by a globule of mercury E. A platinum electrode, sealed into the top of D, is soldered to a silk-covered copper wire that passes out of A through a marine glue plug in the tinned steel screw C and forms the upper connection with a Wheatstone's bridge.

The lower connection is made by a thick copper wire soldered to the bottom of A (not shown). The space between A and D is filled with heavy cylinder oil and the top of the cavity is closed by a tinned steel screw B, five-eighths of an inch in diameter and three inches long, actuated by a large tap wrench. The whole apparatus is surrounded by a tin can, K K, filled with melting ice to keep the temperature constantly at 0° C.

2.



The method used for measuring the changes in the electrical resistance of the mercury thread is illustrated diagramatically in fig. 2. B and G are the battery and galvanometer respectively, P Q equal resistances, R a known resistance, S the mercury thread, and C D a bridge wire. R is made nearly equal to the largest value of S and balance is produced by moving the contact A along the wire. Then if x_0 and x denote two positions of A corresponding to different values of S and β represents the resistance of unit length of the wire, we have for dS, the variation of S between the two settings,

$$dS = \beta(x_0 - x)$$

The sensitiveness and accuracy of the method depend largely on the sharpness of the contact A and the condition of the surface of the wire, but with reasonable care these conditions can be kept constant for a long time.

In a previous communication* I showed that, up to two thousand atmospheres, the relation between the electrical resistance and pressure of mercury is given by the linear equation

$$R = R_0(1 - \alpha P)$$

where R_0 is the initial resistance, R the resistance at the pressure P, and α a constant coefficient. Transposing, we have

$$P = \frac{R_0 - R}{\alpha R_0}$$

* This Journal, IV, iv, p. 1, 1897.

but with the connections described above

$$R_0 - R = \beta(x_0 - x)$$

hence

$$P = \frac{\beta}{a R_0}(x_0 - x)$$

and all the terms except P and x are constant so long as the temperature remains the same. During the present investigation the cylinder containing the mercury tube was surrounded by melting ice nearly an hour before the observations were begun in order that the temperature might become uniform, and after each increment of pressure sufficient time was allowed for the heat of compression to escape. The variation in the temperature of the wire was never more than two degrees and the change in β was negligible. The value of a at 0° C. is ·00003237, and R_0 was so chosen that $\beta/a R_0 = 4{\cdot}09$. Hence

$$P = 4{\cdot}09(x_0 - x)$$

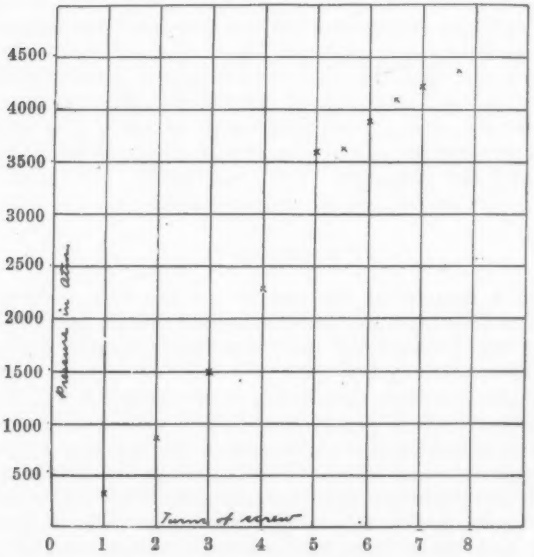
and, since a motion of the contact on the wire equal to two-tenths of a division was clearly indicated by the galvanometer, a change of pressure of one atmosphere could be easily detected.

The apparatus illustrated in fig. 1 was designed primarily to ascertain the limit of pressure attainable with a screw, but the same construction would serve as well for a pressure gauge in connection with any form of compressor by removing the screw B and inserting the connecting tube in its place. The method presents the following advantages. The apparatus is compact and, aside from the resistance boxes, etc., which are to be found in every well ordered laboratory, is inexpensive. It is free from leakage even at very high pressures. Observations can be quickly made and very easily reduced. The constants, except a, can be easily determined. With reasonable care the errors of measurement do not exceed one part in one thousand.

After a preliminary trial with a Bessemer steel screw, that broke when a pressure of 3554 atmospheres had been obtained, a bar of carefully annealed Stubb's steel was turned to fit the thread in A as accurately as possible and then very evenly tinned. Figure 3 exhibits the results of the final observations. The abscissas indicate the angular positions of the top of the screw, one division representing one whole turn, and the ordinates show the corresponding pressures, the scale being 500 atmospheres per division. After five complete turns, when the indicated pressure was 3600 atmospheres, the screw began to twist and it finally broke after 7·7 turns when the maximum

pressure was 4385 atmospheres. Below the yield point of the steel the volume decrement of the substance under compression is proportional to the angle through which the head of the screw is turned, and hence the first five points in this figure lie on a continuous curve without a point of inflection. At higher

3.



pressures the twist of the screw and the shear of its threads destroys the above proportionality and the remaining points lie much lower than they would if the screw had remained rigid up to the point of fracture. No method of accurately determining the extent of the distortion of the steel between the points of yield and rupture was at hand, but if, as is probable, the shear of the threads was small, the above results show that the twist was nearly two complete turns.

Brown University, Sept. 20, 1898.

ART. XLVI.—*The Application of Iodine in the Analysis of Alkalies and Acids;* by CLAUDE F. WALKER and DAVID H. M. GILLESPIE.

[Contributions from the Kent Chemical Laboratory of Yale University—LXXVI.]

IT is well known that when a free mineral acid is added to a neutral mixture of metallic iodate and iodide, the iodate is reduced and iodine is liberated according to the equation:

$$RIO_3 + 5RI + 3H_2SO_4 = 3I_2 + 3R_2SO_4 + 3H_2O.$$

This reaction is complete and non-reversible under the conditions of analysis, and it may therefore be applied to the estimation of amounts of iodate, iodide or mineral acid present in an unknown solution. A solution of iodate to be analyzed is mixed with an excess of iodide and mineral acid, the resulting free iodine estimated by directly titrating with sodium thiosulphate or arsenious acid, and one-sixth of the amount found taken as equivalent to the iodate originally present.* Similarly, a solution of iodide to be analyzed is mixed with an excess of iodate and mineral acid, the resulting free iodine estimated by directly titrating in alkaline solution with arsenious acid, and five-sixths of its amount taken as equivalent to the iodide originally present.† A solution of mineral acid to be analyzed is mixed with an excess of iodate and iodide, the resulting free iodine estimated by directly titrating with sodium thiosulphate, and its entire amount taken as equivalent to the amount of mineral acid originally present.‡ Gröger has applied the last mentioned method to the direct analysis of various mineral acids, and has obtained results manifestly better than those afforded by the use of vegetable indicators. Gröger has also indirectly analyzed solutions of alkali hydroxides and carbonates by adding the solution to be analyzed to a measured volume of mineral acid, previously standardized by the above method, and estimating the small excess of free mineral acid that finally remains by the same method. The only difficulty with the Gröger process lies in the fact that under the conditions present the end-point of the final reaction between iodine and sodium thiosulphate is somewhat obscured by a peculiar back-play of color due to a continuous slow liberation of iodine in the system.

When a solution of a metallic hydroxide is acted on by iodine at a temperature high enough to decompose the small

* Rammelsberg, Pogg. Ann., cxxxv, 493; Walker, this Journal, iv, 235.

† Gooch and Walker, this Journal, iii, 293.

‡ Kjeldahl, Zeitschr. für Analyt. Chem., xxii, 366; Furry, Am. Chem. Jour., vi, 341; Gröger, Zeitschr. für Angw. Chem., 1894, 52.

amounts of hypoiodites that might otherwise be present, the final action results in the formation of an exactly neutral mixture of iodate and iodide, according to the equation :

$$6ROH + 3I_2 = RIO_3 + 5RI + 3H_2O.$$

Phelps* has shown that in the case of barium hydroxide at least this reaction is regular and complete under the conditions of analysis, and is independent of the excess of iodine which remains in the neutral mixture unacted upon, and may be estimated by directly titrating with arsenious acid. Phelps not only applies this principle of action to the standardization of solutions of barium hydroxide by boiling with an excess of iodine in a trapped flask, but also bases thereon a differential method for determining carbon-dioxide, in which the liberated gas is run into a measured amount of barium hydroxide, the final excess of which is estimated by treating with iodine in the presence of the precipitated barium carbonate. The good result obtained by Phelps with barium hydroxide suggested that the attempt be made to analyze alkali hydroxides, and possibly carbonates, by a method, simpler than that devised by Gröger, based on the direct treatment of these compounds with iodine in hot solution. It also seemed possible to apply the differential method not only to carbon-dioxide but to any acid or other compound that will act definitely and completely with the metallic hydroxide employed, provided the soluble or insoluble product formed will not be attacked when heated in the presence of iodine. It was decided to modify the Phelps process, however, in order to obviate the necessity of handling large measured amounts of iodine in a flask trapped to prevent mechanical loss by heating. The flask was therefore dispensed with altogether, and the hydroxide solution to be analyzed was mixed with an approximately measured excess of iodine solution, in an Erlenmeyer beaker, the mouth of which was lightly closed with a little trap to prevent loss by spattering. The excess of iodine was then completely removed by boiling, and the cooled colorless solution remaining, which contained a neutral mixture of iodate and iodide, was acidified with a mineral acid and the liberated iodine titrated with sodium thiosulphate, the amount found being equivalent to the amount of hydroxide taken for analysis.

The present investigation was undertaken to study the limitations and possible applications in analysis of the reactions between iodine on the one hand, and barium hydroxide, potassium hydroxide and sodium carbonate on the other. It was soon found that the reaction in the case of sodium carbonate is entirely dependent on conditions of time, mass and tempera-

* This Journal, ii, 70.

ture, and cannot be pushed to completion except under conditions that make its application in analysis impossible. In the case of barium and potassium hydroxides both the original procedure of Phelps and the modification above described were employed. The modified method was found to be the more convenient and speedy of the two. The results obtained in both cases agreed with one another, but were invariably lower by a small nearly constant amount than those obtained by both the gravimetric and the Gröger processes. This error of the Phelps process and its modification is possibly due to the action of atmospheric carbon dioxide on the hydroxide solution during the short time it is exposed. While it will affect the value of the method as a means of accurately determining the absolute amount of hydroxide present in a given volume of solution, it cannot so affect the accuracy of any differential method founded on the original Phelps process or its modification. This is demonstrated by the work of Phelps in the case of carbon-dioxide, and by the present investigation in the case of hydrochloric and sulphuric acid. Analyses of these two acids were made by adding the solution to be analyzed to a measured volume of barium or potassium hydroxide, previously standardized by the modified Phelps method. The small excess of hydroxide remaining was then estimated by the same method, the results agreeing with those already obtained by both the gravimetric and the Gröger processes. It seems probable that other acids and compounds for which there is now no rapid iodometric method may be analyzed by a method similar to this, that has given good results with carbonic, hydrochloric and sulphuric acids.

Decinormal solutions of the alkali hydroxides were prepared, and kept with great care in trapped bottles, from which portions for analysis were measured by means of a self-feeding burette, which was also fitted with a trap. All vessels and water used were made as free as possible from carbon-dioxide, and the operations were conducted as rapidly as possible.

In the analyses by the Phelps method a carefully measured excess of decinormal iodine was drawn into a small ether wash-bottle, and the desired amount of alkali was rapidly run into it. The stopper, to which had been sealed a Will and Varrentrapp absorption bulb, was placed in the bottle and the bulb was charged with a 5 per cent solution of potassium iodide to catch any escaping vapors of iodine. The apparatus was placed over a low flame and the contents heated to boiling or slightly longer, and then cooled in a stream of water. The contents of the bulb and connecting tubes were then washed into the flask, and the excess of free iodine remaining was titrated with arsenious acid, in the presence of 5^{cm^3} of starch

emulsion. Blank analyses were made to insure against mechanical loss of iodine during boiling and to prevent any error on account of the presence of carbonate or other impurity in the solutions employed.

Some of the results obtained with barium hydroxide are given in Table I. The variation in different analyses of the same series is not large, and the results are independent of the amount taken for analysis and of the excess of iodine employed.

TABLE I.

Analyses of $\frac{N}{10}$ *Barium Hydroxide Solution.*

(By boiling in a trapped flask with an excess of iodine.)

	$Ba(OH)_2$ taken. cm^3.	Iodine taken. grm.	Iodine absorbed by $Ba(OH)_2$. grm.	$Ba(OH)_2$ found. grm.	Mean. grm.	Variation. grm.
(1)	10	0·13	0·1054	0·0712	0·0699	0·0013+
(2)	10	0·14	0·1028	0·0692	0·0699	0·0007—
(3)	20	0·23	0·2072	0·1399	0·1398	0·0001+
(4)	20	0·25	0·2074	0·1401	0·1398	0·0003+
(5)	40	0·44	0·4143	0·2798	0·2796	0·0002+
(6)	40	0·44	0·4148	0·2802	0·2796	0·0006+
(7)	40	0·48	0·4160	0·2809	0·2796	0·0013+
(8)	40	0·48	0·4126	0·2786	0·2796	0·0010—
(9)	40	0·51	0·4115	0·2779	0·2796	0·0017—
(10)	40	0·51	0·4136	0·2793	0·2796	0·0003—

The analyses of potassium hydroxide were made in the same way as were those of barium hydroxide, and gave quite similar results. They follow in Table II.

TABLE II.

Analyses of $\frac{N}{10}$ *Potassium Hydroxide Solution.*

(By boiling in a trapped flask with an excess of iodine.)

	KOH taken. cm^3.	Iodine taken. grm.	Iodine absorbed by KOH. grm.	KOH found grm.	Mean. grm.	Variation. grm.
(1)	10	0·20	0·1621	0·0716	0·0717	0·0001—
(2)	10	0·23	0·1613	0·0715	0·0717	0·0002—
(3)	15	0·30	0·2404	0·1063	0·1076	0·0013—
(4)	15	0·30	0·2429	0·1074	0·1076	0·0002—
(5)	15	0·34	0·2431	0·1075	0·1076	0·0001—
(6)	25	0·51	0·4089	0·1808	0·1792	0·0016+
(7)	25	0·51	0·4058	0·1794	0·1792	0·0002+

The analyses by the modification of the Phelps method were made by drawing into an Erlenmeyer beaker of convenient size an approximately measured excess of decinormal iodine, and rapidly running the desired amount of alkali into it. The

neck of the beaker was then closed by a little trap, made of one of the halves of a double end calcium chloride drying tube, to prevent appreciable loss by spattering. The beaker was then placed over a low flame, and the contents boiled until the last trace of the excess of iodine had volatilized from the solution and the trap. The volume was carefully regulated before and during the boiling, being kept as small as possible, usually amounting to about 100^{cm^3} at the start and 35^{cm^3} at the close. In the case of barium hydroxide care had to be taken to keep the dilution sufficient to prevent the separation of the crystalline barium iodate, which is soluble with difficulty. To steady the ebullition a little spiral of platinum was introduced into the beaker. After the boiling had ceased, the colorless solution, containing a neutral mixture of iodate and iodide, was cooled in running water, and treated with 10^{cm^3} of dilute (1 : 3) hydrochloric acid or (1 : 3) sulphuric acid. The liberated iodine was titrated directly with sodium thiosulphate, in the presence of 5^{cm^3} of starch emulsion. In the case of barium hydroxide, the iodine was liberated with dilute (1 : 3) hydrochloric acid to save the inconvenience of working in the presence of precipitated barium sulphate; with potassium hydroxide, however, dilute (1 : 3) sulphuric acid was employed. In view of a statement by Pickering* that titrations with sodium thiosulphate in the presence of acid involve an error, a series of blank analyses was made which showed conclusively that no such error exists under the conditions which obtain in the process under consideration. Care was also taken, as in a former case, to guard against the possible presence of carbonates or other impurities in the reagents employed.

In Table III are given the results of a series of analyses of barium hydroxide by the modified method just described. They agree fairly well with those of Table I.

The analyses of potassium hydroxide by the modified method are given in Table IV, and are found to agree well with those of Table II.

A gravimetric analysis of the barium hydroxide solution in which the barium was weighed as the sulphate, gave as a result 0·1411 grm. $Ba(OH)_2$ for each 20^{cm^3} taken. An analysis of the same solution by the Gröger process gave for the same volume 0·1420 grm. The result by the Phelps process, however, was 0·1398 grm., and by the modified process 0·1390 grm. That the difference of 2 mg. between the results by the gravimetric and the Gröger processes on one hand, and the Phelps process and its modification on the other, may be due to atmospheric carbon dioxide, has already been pointed out. A gravimetric

* Jour. of the Lond. Chem. Soc., xxxvii, 134.

analysis of the potassium hydroxide solution by evaporating and weighing as KCl gave 0·1111 grm. KOH for each 20$^{cm^3}$ taken, agreeing with 0·1106 grm. obtained by the Gröger process. The analyses by the Phelps process and its modification for the same solution gave 0·1076 grm. and 0·1082 grm. respectively. These results are strikingly in accord with those obtained with barium hydroxide.

TABLE III.

Analyses of $\frac{N}{10}$ *Barium Hydroxide Solution.*

(By boiling with excess of iodine in an open beaker to decoloration, and acidifying the residue.)

	$Ba(OH)_2$ taken. cm^3.	Iodine taken. grm.	Iodine absorbed by $Ba(OH)_2$. grm.	$Ba(OH)_2$ found. grm.	Mean. grm.	Variation. grm.
(1)	10	0·13	0·1023	0·0691	0·0695	0·0004 —
(2)	10	0·16	0·1020	0·0689	0·0695	0 0006 —
(3)	15	0·18	0·1548	0·1046	0·1043	0·0003 +
(4)	15	0·20	0·1546	0·1045	0·1043	0·0002 +
(5)	20	0·23	0·2049	0·1384	0·1390	0·0006 —
(6)	20	0·25	0·2058	0·1390	0·1390	0·0000 ±
(7)	20	0·32	0·2065	0·1394	0·1390	0·0004 +
(8)	25	0·29	0·2567	0·1734	0·1738	0·0004 —
(9)	25	0·32	0·2562	0·1730	0·1738	0·0008 —
(10)	40	0·47	0·4120	0·2783	0·2780	0·0003 +
(11)	40	0·48	0·4119	0·2782	0·2780	0·0002 +
(12)	40	0·48	0·4152	0·2804	0·2780	0·0024 +
(13)	40	0·49	0·4109	0·2775	0·2780	0·0005 —

TABLE IV.

Analyses of $\frac{N}{10}$ *Potassium Hydroxide Solution.*

(By boiling with excess of iodine in an open beaker to decoloration, and acidifying the residue.)

	KOH taken. cm^3.	Iodine taken. grm.	Iodine. absorbed by KOH. grm.	$Ba(OH)_2$ found. grm.	Mean. grm.	Variation. grm.
(1)	10	0·20	0·1624	0·0718	0·0721	0·0003 —
(2)	10	0·23	0·1618	0·0715	0·0721	0·0006 —
(3)	10	0·25	0·1622	0·1717	0·0721	0·0004 —
(4)	15	0·30	0·2459	0·1087	0·1082	0·0005 +
(5)	15	0·34	0·2473	0·1093	0·1082	0·0011 +
(6)	15	0·38	0·2441	0·1079	0·1082	0·0003 —
(7)	20	0·41	0·3274	0·1447	0·1442	0·0005 +
(8)	20	0·46	0·3259	0·1441	0·1442	0·0001 —
(9)	20	0·51	0·3269	0·1445	0·1442	0·0003 +
(10)	25	0·51	0·4052	0·1791	0·1803	0·0012 —
(11)	25	0·57	0·4082	0·1805	0·1803	0·0002 +
(12)	25	0·63	0·4080	0·1804	0·1803	0·0001 +

In the application of the modification of the Phelps process to the indirect analysis of hydrochloric and sulphuric acids the procedure was essentially the same as that detailed for the analyses of barium and potassium hydroxides in Tables III and IV. The acid solution to be analyzed was drawn into an Erlenmeyer beaker, a measured excess of standardized alkali added, and the operation completed as described. It was found that barium hydroxide and potassium hydroxide may be applied with equal accuracy to the analysis of both hydrochloric and sulphuric acids. Some of the results obtained are given in Tables V, VI and VII.

TABLE V.

Analyses of $\frac{N}{10}$ *Hydrochloric Acid Solution.*

(By adding to excess of $\frac{N}{10}$ $Ba(OH)_2$, boiling with excess of iodine to decoloration, and acidifying the residue.)

	HCl taken. cm^3.	$Ba(OH)_2$ taken. grm.	$Ba(OH)_2$ neutralized by HCl. grm.	HCl found. grm.	Mean. grm.	Variation. grm.
(1)	15	0·17	0·1128	0·0480	0·0476	0·0004 +
(2)	15	0·17	0·1118	0·0475	0·0476	0·0001 —
(3)	15	0·17	0·1112	0·0473	0·0476	0·0003 —
(4)	25	0·26	0·1860	0·0791	0·0794	0·0003 —
(5)	25	0·26	0·1866	0·0794	0·0794	0·0000 ±
(6)	35	0·34	0·2634	0·1120	0·1111	0·0009 +
(7)	35	0·34	0·2603	0·1107	0·1111	0·0004 —

TABLE VI.

Analyses of $\frac{N}{10}$ *Hydrochloric Acid Solution.*

(By adding to excess of $\frac{N}{10}$ KOH, boiling with excess of iodine to decoloration, and acidifying the residue.)

	HCl taken. cm^3.	KOH taken. grm.	KOH neutralized by HCl. grm.	HCl found. grm.	Mean. grm.	Variation. grm.
(1)	20	0·14	0·0972	0·0633	0·0633	0·0000 ±
(2)	20	0·14	0·0975	0·0634	0·0633	0·0001 +
(3)	25	0·14	0·1222	0·0795	0·0791	0·0004 +
(4)	25	0·14	0·1207	0·0785	0·0791	0·0006 —

An analysis of the hydrochloric acid solution by the Gröger method, which was found to agree in every case with the gravimetric determination, gave for each 25^{cm^3} 0·0801 grm. of HCl, agreeing with 0·0794 grm. and 0·0791 grm. obtained by the new method. An analysis of the sulphuric acid solution by the Gröger method gave for each 25^{cm^3} 0·1241 grm. of H_2SO_4 agreeing with 0·1246 grm. obtained by the new method.

TABLE VII.

Analyses of $\frac{N}{10}$ *Sulphuric Acid Solution.*

(By adding to excess of $\frac{N}{10}$ $Ba(OH)_2$, boiling with excess of iodine to decoloration, and acidifying the residue.)

	H_2SO_4 taken. cm^3.	$Ba(OH)_2$ taken. grm.	$Ba(OH)_2$ neutralized by H_2SO_4. grm.	H_2SO_4 found. grm.	Mean. grm.	Variation. grm.
(1)	10	0·21	0 0884	0·0506	0·0498	0·0008+
(2)	10	0·21	0·0880	0·0503	0·0498	0·0005+
(3)	15	0·30	0·1328	0·0754	0·0748	0·0006+
(4)	15	0·30	0·1313	0·0751	0·0748	0·0003+
(5)	25	0·43	0·2168	0·1239	0·1246	0·0007—
(6)	30	0·43	0·2600	0·1481	0·1495	0·0014—

This investigation shows that the reaction between iodine and hydroxides of the alkalies and alkaline earths in hot solution is regular and complete under analytical conditions, not being appreciably affected by the mass action of considerable excesses of iodine. The reaction is best applied in analysis by titrating the alkali with an excess of iodine, removing this excess by boiling, and estimating the iodine in the residue. While certain mechanical difficulties may affect the extreme accuracy of the process as a direct means for analyzing alkalies, the action is at all times regular and may be indirectly applied with fair accuracy to the analysis of various acids and possibly to other compounds. The reaction between iodine and alkali carbonates on the contrary is irregular and cannot be made the basis of any analytical process.

Art. XLVII.—*On the Associated Minerals of Rhodolite;* by W. E. Hidden and J. H. Pratt.

In a recent paper on *rhodolite*, a new variety of garnet,* the authors gave a list of the associated minerals, and it is the purpose of this article to describe them more fully. All the minerals have been obtained from the gravel beds of Mason Branch, which empties into the Little Tennessee River about five and one-half miles below Franklin, the county seat of Macon County, North Carolina. These gravel beds have been mined quite extensively for rhodolite by means of hydraulic processes and the species herein described have been found wholly in the concentrates. When the minerals shall have been traced to their source, as they promise to be soon and mining *in situ* inaugurated here, this locality may be expected to become one of unusual interest to mineralogists and geologists.

Quartz.—Compact crystalline and granular quartz is abundant as rolled pebbles and rounded bowlders (rarely weighing above 20 kg.). Crystals are occasionally found but are of very ordinary character. Massive quartz enclosing rhodolite and iolite, often both in the same mass, are not uncommon.

Quartz pseudomorphs.—An important characteristic of the locality is the occurrence of quartz pseudomorphs in the form of isometric dodecahedrons, bearing upon their faces markings exactly like those seen upon garnets. These crystals, sometimes 1^{cm} diameter, are wholly perfect and are rarely irregularly grouped together. They are gray in color and apparently homogeneous, with the exception of numerous inclusions of minute red rutile and black menaccanite. Their density, determined upon a single typical specimen, was 3·203, which was low for garnet and high for quartz. When pulverized and treated with the heavy solution to separate out the rutile and menaccanite, the remaining material was found to be a mixture of colorless quartz and the rhodolite variety of garnet.

The manner of their original formation and what was the original dodecahedral mineral, offer peculiar problems, for the crystals are undoubtedly not ordinary pseudomorphs. They never show any projecting neck or rough broken surfaces such as would indicate a pre-existent cavity through which this material might have passed into a cavernous garnet. It is our intention to study sections of these crystals, to determine if possible, the relation of the quartz and garnet in them, whether there are parallel layers of these minerals or whether the optic

* This Journal, vol. v, p. 291, 1898.

axes of the quartz have a definite relation to the dodecahedral axes.

Corundum.—About one-seventh of the heavier concentrates are corundum crystals, in the form of hexagonal prisms terminated by the base, some of which are 1^{cm} in diameter. The surfaces and edges are usually rough, from natural corrosion while in place. The common color is gray, but pale blue, pink and amethystine shades are often found. Ruby-colored crystals also occur and some of them are nearly transparent. A few of the amethystine crystals would furnish fairly good gems. No corundum has, as yet, been found *in situ* in the valley and no matrix is to be seen left upon the crystals.

Spinel Group.—This group constitutes about five per cent of the concentrates and seems to include the three species, pleonaste, gahnite and chromite.

The *gahnite* has a density of 4·24–4·40 and has been analyzed by Dr. Charles Baskerville* with the following results:

		Ratio.		
Al_2O_3	61·09	·599		= 1·13
FeO	7·78	·108	·530	
ZnO	27·44	·339		= 1·
MgO	3·30	·083		
	99·61			

From the above analysis, the mineral is shown to be the kreittonite or zinc-iron variety of gahnite. The ratio of ZnO : FeO : MgO is close to 12 : 4 : 3, which would give for the formula of this gahnite $(12Zn . 4Fe . 3Mg)O . Al_2O_3$.

The mineral has a clean glassy fracture like that of some dark obsidians and is deep bottle-green by transmitted light. The octahedron alone and in combination with the rhombic dodecahedron were the only forms observed on the crystals. The faces are never smooth but have an irregular and rounded appearance very similar to the so-called "fused quartz." Smooth fragmentary masses are most common, varying in size from 3^{mm} to 1·5^{cm} in diameter and are very free from inclusions.

Of the *chromite* only a few small pieces were found, but these would seem to indicate that there is now or has been a rock of the peridotite character in this valley from which this chromite originated. No basic magnesia rocks are known to be exposed in this locality.

The specimens are kidney-form and about 1^{cm} in diameter. They have a very brilliant luster upon a fractured surface and are of a pitchy-black color. A specific gravity determination gave approximately 4·7.

* University of North Carolina.

Bronzite.—This mineral is rare but occurs as highly etched fragments which are pale yellow to deep brown in color and are perfectly transparent, a very exceptional quality of bronzite. A beautiful silky sheen sometimes shines out from it when held at the proper angle similar to that seen in the chrysoberyl cat's-eye. The largest piece weighed 1½ grams and furnished a beautiful gem, much resembling the brown tourmalines from Ceylon. With the hand dichroscope it exhibited beautiful brown and green colors.

The specific gravity of the mineral is 3·43 and its fusibility 5½ to 6.

A little bronzite has been found associated with a very dark green massive amphibolite occurring as erratic bowlders.

Iolite.—The iolite has been found abundantly embedded in small bowlders of a granular quartz. The rock has very much the appearance of a conglomerate with quartz as the cementing material, and it could be well called an iolite pegmatite.

The surface iolite has undergone alteration and left the quartz cavernous and cellular, and only by breaking these bowlders open can the purer white iolite be obtained. This, however, is not entirely free from alteration, for it shows a thin silky to micaceous coating and shows internally minute scales of mica (biotite?), which lie parallel to the basal plane. The rhodolite garnet is the only mineral as yet identified as occurring directly with the iolite, but staurolite, cyanite, pale green apatite and rutile seem to be present. The minute inclusions of mica give rise to a beautiful golden sheen when the iolite is viewed in the direction of the vertical axis in reflected light, thus promising a new chatoyant gem.

No crystal planes have been observed, the mineral being columnar and varying from 3 to 25^{mm} in diameter and length.

The color is pale yellow to greenish yellow. The mineral is nearly transparent but is wholly devoid of dichroism, so eminent a characteristic of the species. The analysis by Baskerville identifies this mineral as iolite.

The result of the analysis is as follows:

Specific gravity = 2·54

		Ratio.		
SiO_2	47·60	·793		= 9·00
Al_2O_3	36·20	·354		= 4·01
FeO	2·13	·015	·283	= 3·21
MgO	10·73	·268		
CaO	trace			
H_2O	3·14	·174		= 1·98
	99·80			

In the above analysis the ratios only approximate to the generally accepted formula, $H_2O \cdot 4(Mg \cdot Fe)O \cdot 4Al_2O_3 \cdot 10SiO_2$, and it is undoubtedly due to a slight admixture of some hydrated iolite with the material analyzed.

Cyanite, tremolite, fibrolite (?), hornblende, rutile and menaccanite occur, but of a too common order to merit any extended mention in this paper.

Staurolite.—This mineral has a rich garnet red color and is perfectly transparent; being apparently free from its customary inclusions. Its specific gravity is 3·80.

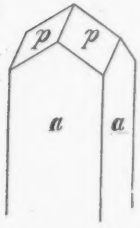
Only small fragments and rounded masses of the staurolite have been found and these were often mistaken by the miners for the pyrope garnet.

Monazite and Zircon.—These two species occur abundantly as minute crystals and grains in the finer and heavier concentrates. They rarely exhibit well-defined crystalline forms but are usually perfectly transparent and very brilliant.

A few rough crystals of monazite were found that were decidedly *green* in color and were from 2–6^{mm} thick in the direction of the *b* axis. This green color would seem to indicate the isomorphous replacement of ThO_2 by UO_2 similar to the occurrence in the green xenotime of Brindletown, N. C.*

Cyrtolite.—Genth† has mentioned the occurrence in this valley of "peculiar dark brown crystals from 1–3^{mm} in size which may be zircon." What are probably the same kind of crystals have been found in the concentrates with the rhodolite, but only two of these were saved. The exterior of the crystals is black or very dark brown, while the interior of one is a yellowish brown. The specific gravity is 3·71.

1.



One of the crystals measured 6^{mm} in the direction of the *c* axis. Orienting the crystals according to zircon, the only forms observed were the prism of the second order *a*, 100 and the unit pyramid of the first order *p*, 111, which were identified by means of the contact goniometer, giving $p \wedge p' = 56° 30'$, while for zircon $p \wedge p' = 56° 40' 26''$. The crystals were smooth and developed as represented in fig. 1, neither of them being doubly terminated.

No analysis has as yet been made of these crystals, but they are undoubtedly hydrated alteration products and should be classified with the so-called malacon and cyrtolite group.

Gold.—A small sample of slightly impure gold was finally saved, after much labor of rewashing the concentrates and

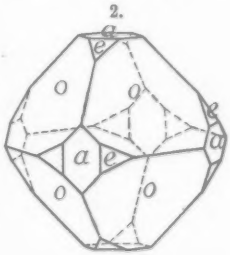
* L. G. Eakins, this Journal, June, 1892.
† Bulletin U. S. Geol. Survey, No. 74, 1891, p. 49.

panning them down to a practical minimum. This sample weighed 1·75 grams and represented the gold from many hundred cubic yards of gravel and thus proved its rarity in this locality.

This gold was assayed and the resulting button weighed 1·2757 grams. Its specific gravity was 17·88. The pure gold weighed after separation from the alloyed silver 1·1583 grams, showing the Mason's Branch gold to be 90·77 per cent "fine." This is interesting because the neighboring Caler Fork (distant two miles N. E.) gold* had a "fineness" of 90·10 per cent and thus a constancy is shown for the region generally. In the concentrates containing this gold, over 300 crystals of sperrylite were found and also all the other characteristic minerals mentioned by one of us as occurring with sperrylite from Caler Fork.*

Sperrylite.—The most important mineral found associated with the rhodolite is sperrylite. It was first found among the gold particles in a similar manner to that discovered by one of us on Caler Fork, in Macon County.*

From the 1¾ grams of impure gold already mentioned, about 300 crystals of sperrylite were finally separated by using a strong pocket lens and a moistened needle point. The gold sands were spread out upon glass to avoid their jumping when touched, as the particles are prone to do from paper or wood. The crystals have sharper edges and are somewhat larger and brighter than those from Caler Fork. The entire "find" did not exceed one milligram in weight and the largest crystal was 0·4^{mm} in diameter. The octahedron apparently predominates, though many of the crystals show an equal development of the cube and octahedron. On a very few of the crystals, there was a slight development of the pentagonal dodecahedron *e*, 210, represented by fig. 2, which was prepared by G. H. Edwards of the Sheffield Scientific School, who identified the faces by the following measurements:



	Measured.	Calculated.
$o \wedge a$, $111 \wedge 010$	54° 56′	54° 44′
$o \wedge o$, $111 \wedge 1\bar{1}1$	70 48	70 32
$a \wedge e$, $100 \wedge 210$	26 28	26 34

These results prove that these sperrylite crystals are isometric and pyritohedral and, therefore, are like the original sperrylite from the Algoma district, near Sudbury, Canada.

* This Journal, vol. vi, p. 381, 1898.

One-half mile due north of the rhodolite placer mine, near the summit of Mason Mountain, a ledge of rock is exposed, which is composed almost entirely of impure rhodolite and biotite, with a very considerable quantity of the iron sulphides disseminated through them. Sperrylite has been obtained by panning the sands naturally concentrated in the crevices and cavities weathered in the ledge, which would seem to indicate that this ledge is one of the original sources, if not *the* source, of the sperrylite found in the valley below.

In conclusion the authors wish to express their thanks to Prof. S. L. Penfield of the Sheffield Scientific School for his kindness in making many tests to positively identify the minerals herein described.

September, 1898.

Art. XLVIII.—*A Revision of the Moraines of Minnesota;* by J. E. Todd.

For our knowledge of glacial deposits of Minnesota, so far as has been published, we are indebted almost entirely to the excellent work of Mr. Warren Upham. Even where others have been employed in detailed work, he has correlated and interpreted the data. The following criticism of his conclusions is done with the most friendly feelings and prompted only by the love of truth. It has seemed advisable that the present view should be presented, that the scientific world might judge for themselves regarding the comparative correctness of the two views.

When called to share in the work of unraveling the Pleistocene geology of Minnesota four years since, the impressions of the writer were mainly in harmony with those of Mr. Upham. It has been his province to examine the northwestern counties of the State, and it should be remembered that the interpretation offered below is based mainly upon observations in the western half of the State. The work in Hubbard and Beltrami Counties soon presented the case in a different light. From a comparison of our map (p. 471, scale, 70 miles to the inch) with those referred to below, the salient differences of interpretation will appear clearly.

It will be seen that, according to Mr. Upham's view, all of the moraines crossing Minnesota and Dakota have been formed by an ice sheet moving southward. Time not permitting us to follow the growth of his views, we take their ripe expression as given in the 22d annual report of the Minnesota Geological Survey. This southerly motion persists without much reference to topography. The stages marked by the separate moraine as recognized by Mr. Upham are as follows:*

1. The Altamont, extending into Southern Dakota and to Des Moines, Ia.
2. Gary Moraine, extending to Mineral Ridge, near Boone, Iowa.
3. Antelope Moraine, extending to Pilot Mound in Hancock County, Ia.
4. Kiester Moraine, extending into Freeborn and Faribault Counties.
5. Elysian Moraine, extending into southern LeSeur County.
6 Waconia Moraine, extending to Waconia, Carver County, Minn.

* Ice Age in North America, pp. 545–. The Glacial Lake Agassiz, Mon. xxv, U. S. G. S., pp. 141–.

7. Dover Moraine, extending into southern Kandiyohi County.

8. Bergus Falls Moraine, which passes Fergus Falls and extends into Morrison County.

9. Leaf Hills Moraine, forming with the preceding the main portion of the Leaf Hills and extending into northern Todd and Morrison Counties, thence east-northeast nearly to Grand Marais on the north shore of Lake Superior.

10. The Itasca Moraine which surrounds Lake Itasca, runs south of Leach and Pokegoma Lakes nearly to Grand Portage on Lake Superior.

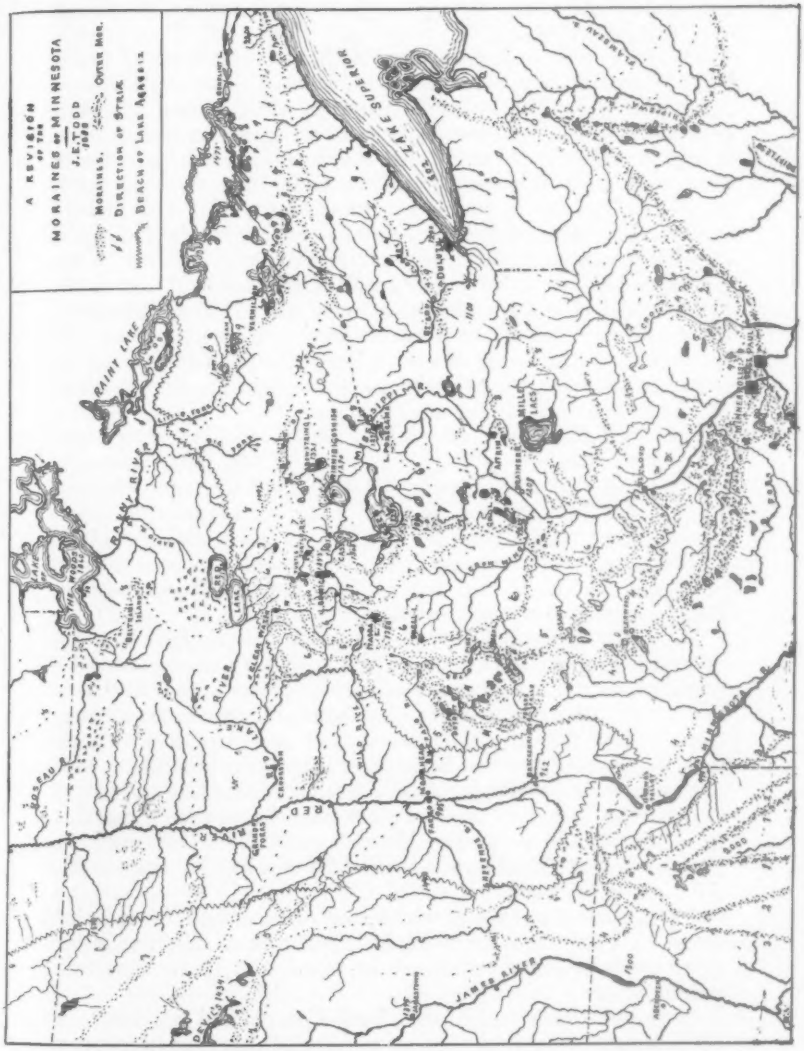
11. Mesabi Moraine, which separates the two portions of Red Lake, lies along the divides of Cass and Winnibigoshish Lakes, thence forms the so-called Mesabi range and strikes Lake Superior at Pigeon Point.

12. Vermillion Moraine, which lies south of Net, Pelican and Vermillion Lakes.

The following objections present themselves to this interpretation:

First, it assumes that latitude had more to do with the movement of the ice sheet than altitude. This is contrary to what we learn either from the movements of existing ice sheets in Greenland and Alaska, or in the case of the Dakota and Michigan lobes of the Pleistocene ice. It is true almost without exception that in the zone of ablation the ice seeks the lowest levels with a persistence nearly equal to that of water. There can be no question that the ice, at least in its later stages, lay in the zone of ablation rather than in the zone of accumulation. The scheme presented above shows little or none of this rule. The ice is represented as vacating the Lake Superior basin and the Red River valley much sooner than it did the elevated region around Itasca. The abrupt rise along the northwest shore of Lake Superior of more than a thousand feet seems not to have exerted any perceptible influence on the direction of the Leaf Hills and Itasca Moraines. In the Mesabi Moraine southeast of Red Lake we find it rising from about 1200 feet at Red Lake to more than 1400 feet on a divide without apparently responding to the influence of the surface at all. In fact, instead of running westward down the slope, as would be analogous to known cases, Mr. Upham represents it as turning eastward so as to form a reëntrant angle.

Second, it does not represent the ice as retiring in the proper direction to explain the formation of the early stages of Lake Superior, when it formed beaches 500 feet above the present lake around its western end and discharged through the St. Croix River. Nor is it in harmony with the subsequent or contemporaneous retreat of the edge of the ice dur-



ing the different stages of Lake Warren. We might add also that it disagrees with the existence of seven or eight moraines as found by Professor F. H. King in the valley of the Upper Flambeaux River, as published in Vol. IV, Geology of Wisconsin. This discrepancy seems to me surprising when we remem-

ber that Mr. Upham strongly argues for the glacial character of these early lakes.

Third, it does not correspond with the directions of striæ. This is particularly true of the striæ at Duluth and Carlton. As reported in Mr. Upham's paper in the 22d annual report of Geol. Survey of Minnesota, the striæ are represented as being prevalently parallel with the axis of Lake Superior or extending west-southwest. Indeed, some are directed north of west. On the same map a number north of the Mesabi range are represented as extending southwest, indicating a decidedly westward movement of the ice in the region in the northern part of Lake County and also about Rainy Lake. Still more decisive are the striæ found along the upper course of Big Fork in southern Itasca County, where the prevalent movement seems to have been westward. Unfortunately, we have not the evidence of striæ to assist us in the western half of the State.

Fourth, this view does not harmonize with the motion of the ice as indicated by bowlders. The White Earth Reservation west of the great divide abounds in limestone bowlders. They are also abundant about Black Duck Lake and Turtle River Lake in Beltrami County, but are rare in the whole of the Mississippi River basin. This is difficult to account for, provided the ice moved for a long time southward from the Red Lake valley into the Mississippi basin.

Mr. J. E. Spurr, in his report of 1893 (Minn. Geol. Survey), calls attention to the fact that the Mesabi range contains bowlders from the north entirely, while the moraine next south "is characterized by the constant presence of large bowlders of the coarse orthosyte and other rocks which are found chiefly from the Keweenawan province and so must have come in a southwesterly direction." He also calls attention to the fact that the area between the southern moraine, which is identified by Mr. Upham with Leaf Hills and the Mesabi Range, is covered with drift similar to that of the moraine mentioned.

Fifth, it does not agree with later observations of morainic areas. As these will be more fully given in a subsequent section, we will simply indicate some of the more significant points here.

In the northern part of Hubbard County and southern part of Beltrami, two moraines were found extending in approximately parallel curves, convex toward the west, one of them forming a reëntrant angle south of Leach Lake.

The moraine about Itasca seems quite as closely connected with the morainic areas southwest as toward the east, and from the topography it seems probable that the ice lingered toward

the south longer because it is at a lower level. About Detroit City and White Earth Agency the drainage is distinctly eastward through the western moraine and down the valley southward. This is indicated by the character of the deposits, which are of a sandy nature and lying in terraces.

Curving westward from the strongly developed north and south moraines upon the divide between the Mississippi and Red River basins, is a short spur south of the Wild Rice River in Norman County and ending abruptly along the Upper Herman beach. A similar westward branch of the moraine turns westward between Hill and Lost Rivers in eastern Polk County. This ends abruptly at a beach marking a lower stage of Lake Agassiz. This is on Section 31, T. 150–40. Moreover, a broad channel with terraces extends from a gap in this moraine southwestward to the beach, indicating a discharge of a stream apparently from the southern edge of the lobe occupying the Red Lake area into Lake Agassiz. The course of Clearwater and Red Lake Rivers, together with a certain subdued unevenness of a belt extending northwest from this point, seems to indicate the location of the edge of the ice in Lake Agassiz during the formation of the moraine.

Having expressed thus definitely our dissatisfaction with the former interpretation, we proceed to outline one that seems to avoid these difficulties.

During the occupation of this region by the ice sheet, we conceive that it moved mainly in two great lobes; one coming from the northeast through the valley of Lake Superior, the other from the northeast and north in the valley of Red Lake and Red River. This latter divided so as to pass down both the James River in Dakota and the Minnesota River. During the Wisconsin stage the two principal lobes mentioned were probably confluent over the whole of Minnesota, except the southeast corner. This was indicated by Mr. Upham in the 9th annual report of the Minnesota Survey, and was followed with some modification by Professor Chamberlain in the 3d annual report of the United States Geological Survey. The main modification was that he conceived the lobes to be more separated by the divide along the Mesabi Range. As the ice receded and stood at intervals to form the different moraines, there was the growth of a long interlobular moraine, first northwest from Minneapolis to the Leaf Hills, thence north and later northeast, following approximately the present divide between the two main valleys, so as to finally connect with the Mesabi moraine. This would evidently derive its material from the western side of the Lake Superior lobe and the eastern side of the western lobe. As different stages were reached in the recession, this interlobular portion would

lengthen along the intersection of the lobes toward the north and later toward the northeast.

As the lobes became more attenuated and separated, the moraines, though still having an acute angle ending in a more or less tapering ridge, would become more divergent toward the south. During the formations of successive moraines, this acute angle would be the scene of copious drainage from the adjacent sides of the two lobes. This drainage would be mostly toward the south. One result of this may be seen in the location of streams, as in the case of the upper portion of Otter Tail River and the Pelican, Buffalo and Wild Rice Rivers. There would also be abundant accumulations of sand and gravel in the form of terraces and plains between the two members of the interlobular moraine. But the matter will be more fully understood after a tracing of the moraines.

The First, or Altamont, moraine was evidently formed when the ice was near its maximum stage in the Wisconsin epoch and probably when the Lake Superior lobe was confluent with the western lobe and its branch occupying the Minnesota valley; so that the moraine was formed extending as far south as Des Moines and thence northwest, passing a little east of Minneapolis and so on northeast quite directly toward Keweenaw Point.

During the formation of the Second, or Gary, moraine, the two sheets of ice began to show their separate character and probably began to accumulate to an indefinite extent heavy deposits of drift extending west and northwest from Minneapolis, possibly uncovered, at least in its later stage, as far west as Wright and Meeker Counties. From the appearance of blue till overlying the red in eastern Minnesota we may infer that some time previous to this stage the western lobe extended farther east. Whether this was before or subsequent to the main accumulations of drift northwest of Minneapolis is undetermined.

During the formation of the Third, or Antelope, moraine, while we may suppose the Lake Superior lobe receded but little, or may, possibly, have advanced somewhat from its closer connection with the fountain of ice northeast. The slender lobe occupying the Minnesota valley receded to a point near the southern line of Minnesota upon the south, and on the southwest had withdrawn from the eastern slope of the Coteau des Prairies. Upon the east it seems to have receded into Meeker and Kandiyohi and Pope Counties. The prominent morainic accumulations along that line may have been partly accumulated at a previous stage. The valley of the north branch of Crow River lay between the Minnesota and Lake Superior lobe at this time.

The Fourth moraine, namely that crossing Lake Traverse and lying along the east side of Big Stone Lake and Minnesota River and connecting with the main moraine upon the east in Pope County, or Mr. Upham's 7th moraine, is quite feebly developed, which corresponds to the reduced strength of the western ice lobe. This rapid recession from the west and south seems a natural consequence of its greater exposure to the warm southwestern winds.

We are unable to follow Mr. Upham in his recognition of the Kiester, Elysian and Waconia moraines, for they seem to us based upon reëntrant angles of the Third moraine. It is probable that during the formation of the Fourth moraine the separation of the ice lobes had extended as far north as the Leaf Hills in the southern part of Otter Tail County. It is impossible, from our present knowledge of the region, to satisfactorily analyze the very complicated tangle of morainic ridges which are included under the general head of Leaf Hills.

In eastern Clay County a spur of the western branch of the interlobular moraine indicates a Fifth moraine, which seems to have been overlooked by Mr. Upham. The junction of this moraine with the highest beach of Lake Agassiz is shown upon the map of Clay County in the second volume of the Geological Survey of Minnesota. At that time, if we interpret rightly, the reëntrant angle of the moraine extended probably as far north as the head waters of the Wild Rice; and considerable drainage from the western lobe escaped down the valley past Detroit by the upper course of Pelican River. Probably at the same time, although not certainly, the edge of the Lake Superior lobe was forming the moraine which passes through range 39 along the east side of Otter Tail River and Otter Tail Lake past Osakis Lake and along Sauk River. It seems not improbable that the morainic portion in eastern Sherburn County belongs to this stage, and even as late as this the ice may not have withdrawn to any extent from the St. Croix River on the east.

South of the Wild Rice another prominent moraine disappears in the bed of Lake Agassiz, which we will call the Sixth. At that time, if we comprehend rightly, the lobes had been separated along the line curving quite sharply eastward in southern Beltrami County. The two members of the moraine pass on opposite sides of the lower Wild Rice Lake and become united and gradually disappear at a point on the divide north of Lake Bemidji. To this stage we would refer, with considerable confidence, the morainic accumulations about Lake Itasca, which, as we have before suggested, we consider a reëntrant angle pointing eastward, owing its existence to the elevated character of that region. The region about Itasca in

places reaches an altitude of 1750 feet, while upon the divide north of Lake Bemidji it is very little over 1400. This difference in level may account for the remarkable extension of the Lake Superior lobe toward the northwest. This we connect with the moraine running east of Shell Lake in Beeker County and more distinctly developed south of Pine Lake and in northern Todd County. In the northeastern corner of that county it changes from an easterly direction to one due south, and includes the morainic accumulations west and east of St. Cloud. Its further development we do not venture to indicate.

The western lobe seems to have continually receded more rapidly than the eastern, and we find again the short portion of a moraine—the Seventh—joining the lower Herman or Norcross Beach of Lake Agassiz in township 150–40. From that point it runs eastward south of Red Lake, probably connecting with a moraine along Big Fork in its eastern course north of Bow String Lake, though it has not been clearly traced. Corresponding in time to this is a moraine found running between Turtle Lake and Lake Bemidji, thence curving southwest, south to southeast through eastern Hubbard County and western Cass County to Gull Lake near Brainard.

There is lying approximately parellel with this a moraine passing north of Cass Lake, crossing the Mississippi east of Lake Bemidji, thence curving toward the south and southeast, forming a prominent reëntrant angle on the south side of Leach Lake. Thence it runs west of south and joins the moraine just mentioned near Gull Lake. Both of these united are believed to correlate with the morainic ridges of interlobular character which lie in Crow Wing and Morrison Counties, the elongated portion trending northeast in northern Kennebeck County, also the ridges in the southern part of the same county and on the south line of Pine County. The distinctly double character of this moraine at its northwestern extension seems to be a result of the unusual elongation of the lobe in that direction. It may be stated also that this seventh moraine shows an indistinct double character.

During the formation of the Eighth, or Mesabi, moraine, we conceive that the two ice lobes had become separated to an indefinite extent, at least beyond the borders of Minnesota, and were forming between them the Mesabi moraine. If we are correct in this supposition, the moraine before mentioned along the Big Fork must have been extended south-eastward so as to connect with the Mesabi. At this stage for some reason the push of the northern ice lobe seemed to have been more strongly southward toward the east; while the southern ice lobe, as in the preceding stage, still pushed strongly northwest. A reason for this may be found in the much steeper slope on

the south side of the divide along Lake Superior. To this stage we refer the morainic ridge separating the two portions of Red Lake, the prominent points of the so-called Beltrami Island south of the Lake of the Woods, the outer portion of the Mesabi range. The course of the moraine around the Lake Superior lobe we do not venture to point out, except to suggest that it may include the moraine south of Lake Pokegama and probably some portions in western Aitkin and Mille Lacs Counties, together with some portions of the singularly elongated ridges trending northeast, portions of which we have referred to the preceding stage. Our conception is that at this time the Superior lobe had become more attenuated and was traversed by channels draining southwest which first tended to form osars; and these eventually grew into interlobular moraines somewhat as McGee has found in eastern Iowa.

During the formation of the Ninth, or Vermillion, moraine the ice lobes had retreated some distance from each other, and the northern was forming the Vermillion moraine as has been traced by Mr. Upham, while the Lake Superior lobe was forming the moraine south of Cloquet River; and probably the northeastern portion of the northeast ridge in Carlton County may have been formed at this time.

In this way we venture to attempt a solution of the unusually perplexing problem of the morainic accumulations of the northwest. The first stage of Lake Superior, when its highest beach was formed and its outlet was by the Bois Brule into the St. Croix River, followed soon after the vacation of this ninth moraine.

Before closing, we may add a few suggestions as to the possible correspondence of the Minnesota moraines on the south side of Lake Agassiz with those traced by Mr. Upham and published upon his map in his work upon Lake Agassiz. We have little difficulty in correlating the first three moraines as has been done in the third annual report of the U. S. Geological Survey. The fourth seems to correspond with the fourth as published in Bulletin 144, U. S. Geological Survey. This may have had upon its western member a double development because of the more rapid retreat of the ice from that direction, which would explain the scattered development of the moraine along the Cheyenne River in North Dakota. The fifth seems to correspond in position with one indicated by Mr. Upham as following up the east side of the Cheyenne River and more distinctly developed south of Devil's Lake. The sixth probably corresponds to the Tiger Hills or the Arrow Hills moraine, and the seventh to the moraine crossing the Manitoba and Northwestern R.R. near Mennidosa on the Little Saskatchewan; while the eighth and ninth moraines extend into regions unknown west of Hudson Bay.

ART. XLIX.—*Preliminary Report on some new marine Tertiary horizons discovered by Mr. J. B. Hatcher near Punta Arenas, Magellanes, Chile;* by ARNOLD E. ORTMANN, Ph.D.

HAVING arrived in Punta Arenas in December, 1897, Mr. J. B. Hatcher directed his attention first to the study of the Tertiary deposits found near the Coal Mines of Punta Arenas. He collected a lot of specimens from these beds, and about the middle of February, 1898, his first shipment of fossils reached Princeton, together with a letter giving stratigraphical notes and a rough sketch of a section of the locality under discussion. The writer has examined the marine fossils of this collection, and thinks it important to give a preliminary report on these beds, since this collection shows that there are represented *two new horizons* different from and older than the Tertiary beds known in Patagonia (Patagonian and Suprapatagonian beds), which contain a marine fauna that is to be regarded as completely new to science.

Although Philippi* has described a couple of species from Punta Arenas and the surrounding country, nothing was known hitherto as to the stratigraphical relations of these fossils. Now, Mr. Hatcher's collection contains a number of Philippi's species, and his notes show conclusively that they are not found in one and the same bed, but belong to *three* different horizons, one of which is apparently identical with Patagonian deposits, while the two others are different and older.

While I do not propose to give a complete geology of these parts—leaving this task to Mr. Hatcher—I may describe the general succession of the beds under discussion, in order to show their relations to each other.

The locality is situated on the bluffs of the northern banks of the Rio de las Minas, which cuts through the strata in a west-easterly direction. The dip of the beds seems to be to the west—quite different from that observed by Mr. Hatcher farther north.†

Mr. Hatcher distinguishes in his notes *five* principal horizons. The *first* (the lowermost) contains only plant-remains (leaves, etc.), the *second* and *third* contain marine shells, the *fourth* represents the Punta Arenas coal, and the *fifth* (the uppermost) contains again marine fossils. He did not send any measurements of the thickness of the respective beds: only the vertical distance of the outcrop of the fifth bed on top of the hills from Punta Arenas is given approximately as 700 feet. Thus

* Die tertiaeren und quartaeren Versteinerungen Chiles, 1887.
† This Journal, vol. iv, November, 1897, pp. 334 and 338.

it seems that the total thickness of these five beds, together with the intermediate, non-fossiliferous strata, amounts to several hundred feet.

Since the *first* and the *fourth* horizons contain only plant remains (the fourth being the Punta Arenas coal, a very black lignite, of which Mr. Hatcher has sent specimens), I shall disregard these beds, and discuss only the horizons II, III and V.

Beginning with the uppermost, the *fifth* horizon, overlying the coal mines, it is to be divided, according to the labels of the specimens, into three subdivisions. Horizon V proper contains most of the fossils: but there are a number of oysters, which are labelled below V, and above V. Thus it seems that the chief horizon V begins and ends with oyster beds.

Now, it is very interesting that the oysters found "above V" agree in every respect with the large oyster of the Cape Fairweather beds discovered by Mr. Hatcher.* This form is *not* found in any of the underlying beds of this section, but it is represented in horizon V *and* "below V" by a form that agrees completely with what I have called *Ostrea philippii*,† which is characteristic for the Suprapatagonian beds of Patagonia (Rio Chalia and Rio Chico).

The list of the fossils found in horizon V proper is the following:

Ostrea philippii Ortm. (= *bourgeoisi* Phil.)
Pectunculus ibari Phil. (= *magellanicus* Phil. = *pulvinatus cuevensis* v. Ih.)‡
Lucina promaucana Phil.
Venus chiloënsis Phil.
Cytherea splendida v. Ih.
Crepidula gregaria Sow. (= *Haliotis imperforata* Phil.)§
Lamna sp. (Tooth).

Disregarding the sharks-tooth, we have *six* species in this bed. *Four* of them (*Ostrea phil.*, *Pectunculus ib.*, *Venus chil.*, *Crepidula gr.*) have been recorded already by Philippi. *Five* species (*Ostrea p.*, *Pectunculus i.*, *Lucina p.*, *Cytherea s.*, *Crepidula g.*) are found in Patagonia, all of them in the Suprapatagonian beds, only two or three also in the Patagonian beds

*See Hatcher, On the Geology of Southern Patagonia, this Journal, vol. iv, November, 1897, p. 345, and Ortmann, On some of the large Oysters of Patagonia, ibid., p. 356.

I no longer believe that this oyster is identical with *O. patagonica* d'Orb. As to the identification of the Patagonian oysters I differ from v. Ihring (Revista Museu Paulista, vol. ii, 1897): but this is not the place to discuss this question in detail.

† See l. c., p. 356, pl. 11, fig. 2.

‡ See v. Ihring, l. c., p. 238, pl. 7, fig. 46, pl. 8, fig 50. The identity of these forms is shown by our series of specimens.

§ *Haliotis imperforata* of Philippi (l. c., pl. 12, fig. 2) is nothing else than a giant *Crepidula gregaria*.

(*Ostrea p.*, *Lucina p.?*, and *Crepidula g.*). Thus it seems—although the number of fossils is quite small—that the identity of our *fifth horizon* with the *Suprapatagonian beds* is warranted, especially, if we take into consideration that some of the species (*Ostrea*, *Pectunculus*, *Crepidula*) are very characteristic forms of these deposits.

In the oyster bed "below V" only oysters of the type of *O. philippii* are found: a single upper valve from the same bed suggests also the presence of *O. hatcheri* Ortm.,* but this valve is not sufficient to make the identification certain.

The beds discussed above are separated from the third horizon by the coal underlying the fifth horizon and its subdivisions. The *third* horizon contains the following fossils:

Ostrea torresi Phil. (abundant).
Cardita spec. nov.
Venus spec. nov. (No. 1) (also in horizon II).
Venus spec. nov. (No. 2).
Cytherea (*?*) *spec. nov.*
Glycimeris spec nov.
Patella spec. nov.†
Trochus (*Calliostoma*) *spec. nov.*
Trochita costellata Phil. (also in horizon II).
Natica chiloënsis Phil. (also in horizon II).

The difference of this fauna from that of horizon V is very striking. None of the species has been found in Patagonia, and most of them are new to science. *Ostrea torresi* is the only one previously recorded from this locality, and it is the only abundant form, the others being much rarer. *Trochita costellata* has been recorded from Lebu, Chile, and *Natica chiloënsis* from the island of Chiloë, both localities being regarded as of the age of the "Navidad Stufe" of Steinmann.‡ The latter two species as well as *Venus spec. nov.* (No. 1) are also represented in the second horizon.

The *second* horizon, the lowermost in the series containing marine fossils, has yielded the following species:

Ostrea sp. ? (only upper valves).
Venus spec. nov. (= No. 1) (also in horizon III).
Dosinia complanata (Phil.)
Glycimeris ibari (Phil.)
Lutraria spec. nov.
Turritella spec. nov. (very abundant).
Trochita costellata Phil. (also in horizon III).

* See l. c., p. 355, pl. 11, fig. 1 (= *O. percrassa* v. Ih., l. c, p. 221).

† Or *Acmæa spec. nov.*

‡ See Philippi, l. c. p. 249 and 250; Steinmann and Moericke, in Neues Jahrbuch f. Miner., etc, Beil. x, p. 593, 1896.

Natica chiloënsis Phil. (also in horizon III).
Struthiolaria spec. nov.
Actæon chilensis Phil.
Bulla remondi Phil.

This fauna again differs from that found in the third horizon, although there are three species (out of ten) identical. *Glycimeris ibari* is the only form previously recorded. *Five* species (*Dosinia c.*, *Trochita c.*, *Natica c.*, *Actæon c.*, *Bulla r.*) have been found in the Navidad beds of Chile, while none of them has been found in Patagonia.

The list of fossils from Magellanes (Punta Arenas, Skyring Water, etc.) given by Philippi*) contains 17 species, one of which (*Turritella patagonica*) was inserted by a mistake (cf. l. c., p. 77), while *Pectunculus ibari* and *magellanicus* are identical, thus leaving 15 species. *Seven* of these are represented in our collection, namely: 1. *Haliotis imperforata* (= *Crepidula gregaria*, 2. *Venus chiloënsis*, 3. *Panopæa ibari* (= *Glycimeris ibari*), 4. *Pectunculus ibari*, 5. *Ostrea bourgeoisi* (= *O. philippii*), 6. *Ostrea patagonica* (probably = Cape Fairweather oyster), 7. *Ostrea torresi*.

No. 1, 2, 4, 5 and 6 are represented in the fifth horizon, No. 7 in the third horizon, No. 3 in the second horizon.

In connection with the general stratigraphical observations made by Mr. Hatcher, the paleontological facts set forth above seem to warrant the following conclusions:

1. There are represented, on the banks of the Rio de las Minas, near Punta Arenas, *three* different horizons yielding marine fossils, the uppermost of which may be subdivided into three subdivisions, and *two* horizons characterized by plant remains. The characteristic fossils of the series are given in the following table:

Horizon:

V. { *c.* Oyster bed, composed of the Cape Fairweather oyster.
{ *b.* Marine fossils: *Ostrea philippii*, *Pectunculus ibari*, *Crepidula*, etc.
{ *a.* Oyster bed, composed of *Ostrea philippii*.

IV. Punta Arenas coal.
III. Marine bed with *Ostrea torresi*.
II. Marine bed with *Turritella*, *Natica chiloënsis*, *Struthiolaria*, etc.
I. Bed with plant-remains.

2. The marine fossils described by Philippi from this locality

*L. c., p. 251.

come from the horizons II, III, and V, and are not all of the same age.

3. Horizon V closely resembles the Suprapatagonian beds of Patagonia. No conclusive evidence has been found indicating the presence of the true Patagonian beds.

4. The horizons II and III have a few species in common. Both differ entirely from V, none of their species having been found in Patagonia. Thus these two horizons form a deposit that is paleontologically and stratigraphically well separated from the Suprapatagonian beds (and paleontologically also from the Patagonian beds).

5. There are some relations of the horizons II and III to the so called Navidad beds of Chile (5 species). Since these latter beds show also very many relations to the Patagonian and Suprapatagonian beds, and since of the five Navidad species found near Punta Arenas none has been found in Patagonia, it is very probable that the Navidad series contains a number of horizons of different age, a part of which is to be compared with these two horizons of Punta Arenas, while another part is identical with Patagonian deposits.*

6. Since we have ample reason to consider the Suprapatagonian beds as of *Miocene* age,† the question of the geological age of horizon V seems to be settled. As to horizons II and III, stratigraphical evidence points to an older age, perhaps *Eocene*, and the general character of the fossils does not contradict this assumption. But it is well to be noted that very few, if any, direct confirmations of the Eocene age have been found by a comparison of the species with those of known Eocene faunas. On the other hand, Cretaceous age of these two horizons seems to be out of the question, since no characteristic Cretaceous fossils have been discovered, although such forms (Ammonites) are known from a locality not far away (Port Famine).

I hope Mr. Hatcher will again direct his attention to these beds, and, if possible, settle the question of their relation to the Cretaceous deposits of Port Famine as well as the question of the lack of true Patagonian beds in this region. A complete account of the geology of these parts will be given by Mr. Hatcher after his return from Patagonia.

Princeton University, September, 1898.

* This view is supported by the thickness of the Navidad beds. Darwin gives 800 feet for the cliffs forming the Navidad beds (Geol. Observ. South America, 1846, p 127).

† Compare Hatcher, l. c, p. 337 ff, and Moericke, l. c., p. 593 and 596.

ART. L.—*The Comparative Value of Different Kinds of Fossils in Determining Geological Age;** by O. C. MARSH.

MORE than twenty years ago, my attention was called to the subject of the difference between the value of fossil Plants, Invertebrates, and Vertebrates, as evidence of the geological age of the strata in which they were preserved. On the comparative value of these different groups of fossils then depended the solution of some grave problems in the geology of the Rocky Mountains. I therefore began a systematic investigation of the subject, and gave the results in an address before the American Association for the Advancement of Science, in 1877.† I stated the case as follows:

"The boundary line between the Cretaceous and Tertiary in the region of the Rocky Mountains has been much in dispute during the last few years, mainly in consequence of the uncertain geological bearings of the fossil plants found near this horizon. The accompanying invertebrate fossils have thrown little light on the question, which is essentially whether the great Lignite series of the West is uppermost Cretaceous or lowest Eocene. The evidence of the numerous vertebrate remains is, in my judgment, decisive, and in favor of the former view.

"This brings up an important point in paleontology, one to which my attention was drawn several years since; namely, the comparative value of different groups of fossils in marking geological time. In examining the subject with some care, I found that, for this purpose, plants, as their nature indicates, are unsatisfactory witnesses; that invertebrate animals are much better; and that vertebrates afford the most reliable evidence of climatic and other geological changes. The subdivisions of the latter group, moreover, and in fact all forms of animal life, are of value in this respect, mainly according to the perfection of their organization or zoological rank. Fishes, for example, are but slightly affected by changes that would destroy reptiles or birds, and the higher mammals succumb under influences that the lower forms pass through in safety. The more special applications of this general law, and its value in geology, will readily suggest themselves."

In the statement I have quoted, I had no intention of reflecting in the slightest degree on the work of the conscientious paleobotanists who had endeavored to solve the problem with the best means at their command. I merely meant to suggest that the means then at their command were not adequate to the solution.

* Abstract of Communication made to Section C, British Association for the Advancement of Science, Bristol Meeting, September 9, 1898.

† This Journal, vol. xiv, pp. 338–378, November, 1877.

It so happened that one of the most renowned of European botanists, Sir Joseph Hooker, was then in America, and to him I personally submitted the question as to the value of fossil plants as witnesses in determining the geological age of formations. The answer he made fully confirmed the conclusions I had stated in my address. Quoting from that, in his next annual address as president of the Royal Society, he added his own views on the same question.* His words of caution should be borne in mind by all who use fossil plants in determining questions of geological age.

The scientific investigation of fossil plants is an important branch of botany, however fragmentary the specimens may be. To attempt to make out the age of formations by the use of such material alone is too often labor lost, and must necessarily be so. As a faithful pupil of Goeppert, one of the fathers of fossil botany, I may perhaps be allowed to say this, especially as it was from his instruction that I first learned to doubt the value of fossil plants as indices of the past history of the world. Such specimens may indeed aid in marking the continuity of a particular stratum or horizon, but without the reinforcement of higher forms of life can do little to determine the age.

The evidence of detached fossil leaves and other fragments of foliage that may have been carried hundreds of miles by wind or stream, or swept down to the sea-level from the lofty mountains where they grew, should have but little weight in determining the age of the special strata in which they are imbedded, and failure to recognize this fact has led to many erroneous opinions in regard to geological time. There are, however, fossil plants that are more reliable witnesses as to the period in which they lived. Those found on the spot where they grew, with their most characteristic parts preserved, may furnish important evidence as to their own nature and geological age. Characteristic examples are found among the plants of the Coal Measures, in the Cycads of Mesozoic strata, and in the fossil forests of Tertiary and more recent deposits.

The value of all fossils as evidence of geological age depends mainly upon their degree of *specialization*. In the Invertebrates, for instance, a Linguloid shell from the Cambrian has reached a definite point of development from some earlier ancestor. One from the Silurian or the Devonian, or even later formations, however, shows little advance. Even the recent forms of the same group have no distinctive characters sufficiently important to mark geological horizons.

* Proceedings Royal Society of London, vol. xxvi, pp. 441–443, 1877.

If we take the Ammonites as another example from the invertebrates, the case is totally different. From the earliest appearance of this family, the members have been constantly changing, developing new genera and species, each admirably adapted to mark definite zones or horizons, and already used extensively for that purpose.

The Trilobites offer another example of a group of invertebrates ever subject to modification, from the earliest known forms in the Cambrian, to the last survivors in the Permian. They, too, are thus especially fitted to aid the geologist, as each has distinctive features, and an abiding place of its own in geological time.

The above examples are all marine forms, and from their abundance, wide distribution, both in time and space, are among the best of all witnesses in marking the succession and duration of changes in geological history.

If we turn now to the fresh-water Mollusca, we find among them little evidence of change from the Palæozoic forms to those still living, and can therefore expect little assistance from them in noting the succeeding periods during their life-history.

Among the fossil Vertebrates, the same law as to specialization holds good. The value of particular groups as witnesses of geological changes depends largely on their own susceptibility to change, and this is equally true of single genera and species. There are indeed some primitive vertebrates, especially among the Fishes, that appear to have changed little during their geological life. The genus *Lepidosteus* is a good illustration, and hence it is of limited value as evidence of what has taken place during its known geological history. Other fishes, however, are much better witnesses of the past.

The Reptiles as a class offer still better evidence of geological changes, and in many instances may be used to advantage in marking horizons. The great sub-class of Dinosaurs, from their beginning in the Triassic, show marked changes of development throughout the whole of Mesozoic time. During the Cretaceous, highly specialized forms made their appearance, and at the close of this period when all became extinct the last survivors were the strangest of all, reminding one, in their bizarre forms, of the last stages of the Ammonites, their cotemporaries. The Crocodiles, too, show great changes during Mesozoic time, and are thus of much value in determining geological horizons. So, also, are the Pterodactyles, and many other extinct reptiles, each according to the degree of specialization attained.

The Mammals, however, are by far the most important class for marking geological time, as their changes and the high degree of their specialization furnish the particular characters that are most useful to the geologist in distinguishing definite zones, and the more limited divisions of the strata containing their remains. The few mammals known from the Trias are so peculiar that they can only give us hints of what mammalian life then was, but in the Jurassic the many forms now known offer important testimony as to the different horizons in which their remains are found. This is true also of the known mammals from the Cretaceous; all are of special value as witnesses of the past.

During Tertiary time, however, the enormous development of the class of mammals, their rapid variations, and, most important of all, the highly specialized characters they develop, offer by far the best evidence of even the smaller changes of climate and environment that mark their life-history throughout. The ungulates alone will answer the present purpose as an illustration, and even one group, the horses, will make clear the point I wish to bring before you.

Near the base of the Eocene the genus *Eohippus* is found, representing the oldest known member of the horse tribe. Higher up in the Eocene *Orohippus* occurs, and still higher comes *Epihippus*, near the top of the Eocene. Again through the Miocene more genera of horses, *Mesohippus*, *Miohippus*, and others, follow in succession, and the line still continues in the Pliocene, when the modern genus *Equus* makes its appearance. Throughout this entire series, definite horizons may be marked by the genera, and even by the species of these equine mammals, as there is a change from one stage to the other, both in the teeth and feet, so that every experienced paleontologist can distinguish even fragments of these remains, and thus identify the zones in which they occur.

This is true of every group of mammals, although not to an equal extent, so that in this class we have beyond question the best means of identifying the age of Tertiary strata by their fossil remains.

I have thus briefly pointed out some of the evidence on which a decision may be reached as to the value of the different kinds of fossils, Plants, Invertebrates, and Vertebrates, in determining the age of strata. All evidence of this kind is of value, but it is the comparative value of each group that is the important point I wish to emphasize, and I have brought the matter before this Section of the Association in the hope that a better understanding on this question may be reached among geologists, in the interest of the science to which we are all devoted.

Art. LI.—*On the Families of Sauropodous Dinosauria;** by O. C. Marsh.

The subclass Dinosauria as known to-day, I have divided into three orders: the *Theropoda*, or carnivorous forms; the *Sauropoda*, or herbivorous quadrupedal forms; and the *Predentata*, also herbivorous, and including several suborders; namely, the *Stegosauria* and *Ceratopsia*, both quadrupedal, and the *Ornithopoda*, containing bipedal bird-like reptiles.†

The principal characters of the order *Sauropoda*, here discussed, may be briefly stated as follows:

Order Sauropoda.

External nares at top of skull; premaxillary bones with teeth; crowns of teeth rugose, and more or less spoon-shaped; large antorbital openings; no pineal foramen; alisphenoid bones; brain case ossified; no columellæ; postoccipital bones; no predentary bone; dentary without coronoid process. Cervical ribs coössified with vertebræ; anterior vertebræ opisthocœlian, with neural spines bifid; posterior trunk vertebræ united by diplosphenal articulation; presacral vertebræ hollow; each sacral vertebra supports its own sacral rib, or transverse process; no diapophyses on sacral vertebræ; neural canal much expanded in sacrum; first caudal vertebra biconvex; anterior caudals procœlian. Sternal bones parial; sternal ribs ossified. Ilium expanded in front of acetabulum; pubes projecting in front, and united distally by cartilage; no postpubis. Limb bones solid; fore and hind limbs nearly equal; metacarpals longer than metatarsals; femur longer than tibia; astragalus and calcaneum not fitted to end of tibia; feet plantigrade, ungulate; five digits in manus and pes; second row of carpal and tarsal bones unossified; locomotion quadrupedal.

(1) Family *Atlantosauridæ*. A pituitary canal; large fossa for nasal gland. Distal end of scapula not expanded; coracoid quadrilateral. Sacrum hollow; ischia directed downward, with expanded extremities meeting on median line. Anterior caudal vertebræ short, with lateral cavities; remaining caudals solid; chevrons single.

Genera *Atlantosaurus*, *Apatosaurus*, *Brontosaurus*. Include the largest known land animals. Jurassic, North America.

* Abstract of Communication made to Section D, British Association for the Advancement of Science, Bristol Meeting, September 12, 1898.

† The Dinosaurs of North America, Sixteenth Annual Report, U. S. Geological Survey. 84 plates. Washington, 1896.

(2) Family *Diplodocidæ*. External nares at apex of skull; no depression for nasal gland; two antorbital openings; large pituitary fossa; dentition weak, and in front of jaws only; brain inclined backward; dentary bone narrow in front. Scapula with shaft somewhat enlarged at summit. Ischia with shaft expanded distally, directed downward and backward, with sides meeting on median line. Sacrum hollow, with three coössified vertebræ. Anterior caudal vertebræ procœlian, with sides deeply excavated, and chevrons single; median caudals excavated below, with chevrons double, having both anterior and posterior branches; distal caudals elongate, with rodlike chevrons.

Genera *Diplodocus* and *Barosaurus*. Jurassic, North America.

(3) Family *Morosauridæ*. External nares anterior; large fossa for nasal gland; small pituitary fossa; dentary bone massive in front; teeth very large. Shaft of scapula expanded at distal end; coracoid suboval. Sacral vertebræ four in number, and nearly solid; ischia slender, with twisted shaft directed backward, and sides meeting on median line. Anterior caudals solid; chevrons single.

Genera *Morosaurus*, *Camarasaurus* (?) (Amphicœlias). Jurassic, North America and Europe.

(4) Family *Pleurocœlidæ*. Dentary bone constricted medially; teeth with crowns like those of *Diplodocus*. Cervical vertebræ elongate, centra hollow, with large lateral openings; sacral vertebræ solid, with lateral depressions in centra; caudal vertebræ solid; anterior caudals with flat articular faces, and transversely compressed neural spines; median caudal vertebræ with neural arches on front half of centra. Ischia with compressed distal ends, and sides meeting on median line.

Genera *Pleurocœlus*, *Astrodon* (?). Jurassic, North America and Europe. Include the smallest known *Sauropoda*.

(5) Family *Cardiodontidæ*. Teeth of moderate size. Upper end of scapula expanded; humerus elongate; fore limbs nearly equaling hind limbs in length. Sacrum solid; ischia with wide distal ends, and sides meeting on median line. Caudal vertebræ biconcave; median caudals with double chevrons.

Genera *Cardiodon* (Cetiosaurus), *Bothriospondylus*, *Ornithopsis*, and *Pelorosaurus*. European, and probably all Jurassic.

(6) Family *Titanosauridæ*. Fore limbs elongate; coracoid quadrilateral. Presacral vertebræ opisthocœlian; first caudal vertebræ biconvex; remaining caudals procœlian; chevrons open above.

Genera *Titanosaurus* and *Argyrosaurus*. Cretaceous (?), India and Patagonia.

Art. LII.—*A Biotite-tinguaite Dike from Manchester by the Sea, Essex County, Mass.;* by Arthur S. Eakle.

The dike described in this paper cuts through the augite-syenite of Gales rocks, 200 yards south of Gales Point, Manchester, and was discovered in July, 1896, by Mr. J. H. Sears, while investigating the rocks of that vicinity. The writer has not seen the dike, and all of the data regarding its occurrence, and the material for the petrographical and chemical study, has been very kindly supplied by Mr. Sears. "The dike is 6 inches wide and is exposed for 20 feet, cutting the augite-syenite in a nearly horizontal position, six feet below the surface of the mass of syenite. It is only exposed at low water, as at high tide the entire mass of syenite is submerged." The occurrence of this ægirine dike in the immediate vicinity of the tinguaite dike at Pickards Point, which was first described by Sears* and lately shown to be an analcite-tinguaite by Washington,† might naturally lead to the supposition that the two dikes would be similar in many respects, yet both macroscopically and microscopically they are quite dissimilar rocks.

The rock has a greenish-gray color and a slightly greasy luster, like tinguaites and rocks rich in nepheline. Small phenocrysts of feldspar are visible in the somewhat compact groundmass, and also much magnetite, mixed with biotite, occurs in brownish-black patches, giving the rock a mottled appearance. The structure is compact, holocrystalline, the rock resembling a phonolite, breaking with an even fracture and weathering to a light gray color.

Under the microscope the principal constituents are seen to be feldspathic laths and plates with much nepheline and less amounts of ægirine, magnetite and biotite. Besides these prominent minerals, hematite, a little sodalite, a few apatite and zircon needles, and minute sections of purple fluorite are present.

The feldspar is the most abundant constituent and predominates in lath-shaped sections, most of which have a broken, ragged appearance, due to frayed-out ends and a fibrous structure. This fibrous appearance is evidently the result of lamellar intergrowths of the soda and potash feldspars, microcline and albite, forming microcline-microperthite. Some of the broader sections show a rather coarse intergrowth of the two feldspars, giving extinctions on different parts corresponding respectively to those of microcline and albite. The character-

* J. H. Sears, Bull. Essex Inst., vol. xxv, 4, 1893.
† This Journal, IV, vol. vi, p. 182, 1898.

istic moirè appearance of anorthoclase is lacking, the sections showing multiple extinctions and appearing more as perthitic intergrowths than as homogeneous mixtures of the two feldspars. Carlsbad twinning is quite common. The visible phenocrysts are brachypinacoidal plates of albite which show basal and prismatic cleavage cracks.

Nepheline is next to the feldspars in amount and plays the role of quartz, filling the interspaces formed by the network of feldspar laths. Having been the last mineral to form, most of it is consequently in xenomorphic, angular sections, but here and there a well-defined hexagonal plate is seen. The sections are mostly altered to a grayish, muddy, granulated material which is apparently a mixture of nepheline with kaolin and very fine granular quartz, the alteration proceeding to a hydrous aluminium silicate, with a separation of some free silica, rather than to a zeolite. They still retain their index above that of the neighboring feldspar and gelatinize to some extent with HCl, as shown by fuchsin staining.

Ægirine is disseminated in the rock, in fragments and small crystals, in sufficient amount to give the rock its slightly greenish cast. Its crystallization preceded that of the feldspars and it is now present as rounded crystals or broken, irregular fragments. The sections vary from deep grass-green to almost colorless, and the more deeply colored show a marked pleochroism, a = bluish green, b = grass green, c = greenish yellow; the axis of greatest elasticity lies nearest c, and the extinction is practically parallel in most of the sections.

Magnetite is common and marks the remains of plates of a former dark silicate. Most of this original silicate has entirely disappeared, leaving only the black patches of secondary magnetite, but an occasional section shows a greenish-brown mineral between the heavy black borders, which from its absorption, parallel extinction, and characteristic shimmer, is evidently biotite or perhaps lepidomelane. From the similarity of all the black sections it is reasonable to infer that they were originally this biotite, and since the analysis shows so little magnesia in the rock, the biotite must have been very poor in this oxide and high in iron. Washington notes the poverty of magnesia in all of the rocks of Essex County, so far analyzed by him.

Sodalite is seen in small, colorless isotropic sections of low refraction and showing dodecahedral cleavage. The amount however is much too small to account for all of the chlorine in the analysis, and it is quite probable that most of the chlorine is due to impregnation from the sea water. None of the small amount of isotropic mineral in the slide is believed to be analcite, and the dike can hardly be included in the same class with the one at Pickards Point.

The structure of the rock differs from that of a typical tinguaite, in that the component feldspar and ægirine minerals do not occur as needles, but as much stouter lath-shapes and prismatic crystals, indicating a slower rate of cooling of the magma and thus producing a phase of tinguaite much less dense and more holocrystalline than common. The rock is classed here as a biotite-tinguaite, yet from the presence of many feldspar sections tabular to M, it can as well be considered a phase of sölvsbergite. It stands intermediate between a quartz-free nepheline tinguaite and a nepheline-ægirine sölvsbergite; such a rock is described by Brögger from a dike between Tjose and Åklungen.*

The analysis gives:

SiO_2	60·05
TiO_2	0·11
Al_2O_3	19·97
Fe_2O_3	4·32
FeO	1·04
MnO	0·79
CaO	0·91
MgO	0·23
K_2O	3·24
Na_2O	7·69
H_2O 110°	0·15
H_2O ig.	1·26
Cl	0·28
	100·04

The specific gravity determined by the balance is 2·708.

Access to the dike is very difficult, and all of the specimens obtained come from near the surface and have weathered enough to make it difficult to estimate, even approximately, the relative proportions of the mineral contents from the chemical analysis. The nepheline and biotite show the greatest amount of alteration and the rock has apparently lost some of its alkalies and iron from the change, through its exposed condition. The amount of silica and alumina is more than sufficient to combine with the alkalies to form the alkali minerals, and the excess is present in the form of kaolin and secondary quartz. Fully 20 per cent of the slide appears to be nepheline, yet the percentage of soda will only allow for about one-half of this amount, and 14 per cent only of the rock is soluble in HCl. A calculation from the percentage composition, with due regard to the microscopical estimation, gives the following as an approximate mineral composition of the rock in its present state:

* Die Eruptivgesteine des Kristianiagebietes, Part I, p. 99.

47·16	$Na_2Al_2Si_8O_{16}$	67·28 per cent feldspar.
16·68	$K_2Al_2Si_8O_{16}$	
3·44	$CaAl_2Si_2O_8$	
9·61	$Na_6K_2Al_8Si_9O_{34}$	20·32 nepheline, kaolin and quartz.
8·09	$H_4Al_2Si_2O_9$	
2·62	SiO_2	
6·00	$Na_2Fe_2Si_4O_{12}$	6·00 ægirine.
2·90	biotite.	
3·50	$Fe_2O_3(FeMn)O$	6·40 biotite and iron oxides.
100·		

The remaining minerals, sodalite, apatite, zircon and fluorite, would probably form less than one per cent of the rock. The same relative proportions of the minerals in a perfectly fresh rock would require about one and one-half per cent more of combined alkalies, with a corresponding decrease in the combined silica and alumina.

Mineralogical Laboratory, Harvard University, September, 1898.

ART. LIII.—*Descriptions of new American Actinians, with critical notes on other species*, I.; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. LVIII.

Sagartia Luciæ, sp. nov. Figure 1, p. 497.

A SMALL, very smooth, highly contractile species. In usual expansion the column may be cylindrical; its height may be less than its diameter or twice as great; it is often distinctly fluted, but has no trace of adhesive suckers. Cinclides are not visible, but white acontia are emitted freely from the sides of the body, irregularly, and from the mouth. The column is usually dark green, or olive-green, often tinged with orange, and is striped with 12 (sometimes 24) narrow bright orange or white lines, corresponding to the 12 larger tentacles and mesenterial interspaces.

Tentacles, in the larger examples, 60 to 84, more commonly 48, arranged in four ill defined rows, long, slender, tapered, capable of sudden contraction; the length of the 12 inner ones is often twice the diameter of the body or more; the two directives (a, a') are slightly longer than the other primaries. The tentacles are pale green or greenish white, sometimes tinged with salmon, and sometimes specked with white; the larger ones are often darker green at base, and whitish on the inner side of the base, especially the directives.

Disk changeable, flat, concave or convex, greenish, marked with narrow dark radial lines and crossed by a conspicuous bar of flake-white, in line with and including the bases of the directive tentacles, and embracing the sides of the mouth; smaller radial white spots may stand in front of other tentacles. Lips light red, with several small lateral folds and two gonidial grooves.

Height of column usually about ·25 inch (5 to 8^{mm}); diameter 4 to 6^{mm}; length of tentacles 6 to 10^{mm}.

New Haven, Conn., to Woods Holl, Mass., in tidal pools, from half-tide to low-water mark, both freely exposed and concealed under stones and in crevices.

It is very abundant in the small tide-pools situated at about half-tide on the ledges of "Outer Island," near New Haven, where I have studied it during six seasons. In some of these pools the water is not more than one or two inches deep and in winter it freezes to solid ice each day; while in summer it becomes heated to 95° F., or even more, without injury to this apparently delicate actinian. Moreover, when rain falls during the recession of the tide, the sea-water in these small pools is

washed away and replaced by fresh water for several hours, destroying most other kinds of marine life, but apparently without injury to this species. At least, I have found them as active as usual the next day. Such pools are also exposed to heavy seas and the pebbles and cobble stones that often fill them are violently tossed about by the waves, and yet I have often found the actinians as lively as ever immediately after the severest storms.

It is, therefore, one of the hardiest species known. It expands freely and almost constantly in confinement.

In the upper tide-pools it is often associated with young oysters and mussels, and with the common rock barnacle (*Balanus balanoides*). The English periwinkle (*Littorina littoralis*) also abounds in the same pools. This *Sagartia* is often attached to the mussels and oysters, as well as to the exposed ledge and under sides of stones, etc. Sometimes it is found on *Chondrus crispus* and other algæ. Dr. W. E. Coe has found it in New Haven harbor, and informs me that he also found it common at Woods Holl, Mass., this season, but during the nine seasons that I spent at that station studying the fauna, between 1871 and 1887, I did not find it, though careful search was made every season for small organisms in suitable localities. The same is true in respect to the region about New Haven, which was carefully searched by me, during many years, from 1865 to 1890, without finding this species. So we must conclude that it has very much increased in numbers in this region within a few years, like several other species. It may have been introduced from further south, on the oysters that are annually brought north, in large quantities, and planted in our waters.

My attention was first called to this species, as something new, in 1892, by my young daughter, Miss Lucy L. Verrill, for whom I have named it. She found it in the tidal pools at Outer Island, Conn. It was then much less abundant that at the present time.

Specimens collected early in November often contain numerous small ciliated embryos, which may be seen swimming about inside the translucent tentacles.

This species belongs to that section of the genus *Sagartia* for which Gosse proposed (1860) the name *Thoë*, characterized by the smoothness of the column, no adhesive suckers being visible. Our species is entirely smooth, and I have never seen any adherent particles of sand or mud.

The typical species of *Sagartia* (*S. miniata*, etc.) have numerous small adhesive papillæ or suckers on the upper part of the column. The same is true of the genus or subgenus *Cylista* Gosse, 1860. Additional figures of this species have been prepared for a subsequent paper.

Sagartia (*Thoë*) *leucolena* Ver.

Sagartia leucolena Verrill, Proc. Boston Soc. Nat. Hist., x, p. 336, 1865; Amer. Naturalist, ii, p. 261; Rep. on Invert. of Vineyard Sd, etc., pp. 444, 329, etc., pl. 38, fig. 284, 1874; Radiata North Carolina, this Journal, iii. p. 436, 1872.
Cylista leucolena Andres, Attinie Golfes Neapel, p. 151, 1884.

This species also has a smooth column, without any adhesive suckers, though the scattered cinclides show distinctly, as pores, when living specimens are viewed by transmitted light. Therefore it does not belong to *Cylista*, to which Andres referred it, for the latter has very evident suckers.

It is easily distinguished from *S. Luciæ* by its very elongated, often flaccid, column, which is translucent flesh-color or salmon-color, and by the pale translucent disk and tentacles, without any strong markings. This species lives in the same region as the preceding and is often associated with it, near low-water mark, under stones. It ranges southward to North Carolina.

Actinia Bermudensis, sp. nov.

Column smooth, changeable in form, usually, in expansion, about as high as broad, often broader than high, capable of contracting to a low hemispherical form, with tentacles entirely concealed, but it contracts rather slowly. There is a distinct, strong, submarginal fold, just below the acrorhagi. These are marginal, very large, hemispherical or verruciform, not very numerous (about 24), bright blue. They are often concealed by the fold below them. Tentacles numerous, usually 72 to 96, rather stout, elongated, arranged in several circles in the larger examples; when fully extended the longest are often as long as the diameter of the disk, or even exceed it. The mouth is large with a strong gonidial groove at each end, bordered by prominent lobes; sides of mouth with numerous small folds.

Color of column usually bright cherry-red, sometimes dark red, crimson, or rose-red. Tentacles paler than the column, but usually of the same general color, or brighter. Lips often bright red or carmine. Acrorhagi bright blue. Disk similar to the tentacles.

Height of column up to 1·5 inches (30 to 40^{mm}); diameter up to 1·75 inches or more (40 to 50^{mm}).

Bermuda Islands on the under side of large stones at and above low-water mark, especially at Bailey's Bay and Castle Harbor. (A. E. Verrill and party, 1898.)

Var. *ferruginea*.

A variety, apparently of the same species, was occasionally observed, in the same localities, in which the color of the col-

umn was plain yellowish brown; tentacles a lighter tint of the same. Acrorhagi without differentiated pigment and hence not conspicuous. The form of the body and tentacles were the same as in the typical variety.

This species closely resembles some of the varieties of the common European species, but appears to differ especially in the less numerous and larger acrorhagi, and in the fewer and larger tentacles. Figures of this species will soon appear in the Trans. Conn. Acad. Science.

Epicystis Ehr., Corall. rothen Meeres, p. 44, 1834.

Phymanthus (pars) Andres, Attinie Golfes Neapel, p. 285, 1884 (*non* Edw.).

The generic name *Epicystis* was proposed for the *Actinia crucifera* Les., *A. ultramarina* Les., and *A. granulifera* Les., the first being put in Sect. *a*. Therefore it is necessary to take the former as the type of the genus, which is evidently entirely distinct from the true *Phymanthus*.

Epicystis crucifera Ehr., Corall. rothen Meeres, p. 44, 1834.

Actinia crucifera Leseur, Journ. Acad. Nat. Sci. Philad., i, p. 174, 1817.
Phymanthus crucifer Andres, Attinie Golfes Neapel, p. 286. McMurrich, Actinaria Bahama Is., p. 51, pl. ii, fig. 1, general, pl. iv, figs. 6–11, anatomy, 1889; Duerden, Journ. Inst. Jamaica, ii, p. 452, 1898.

This species is common in crevices and holes of the coral reefs of Bermuda, where I collected specimens which were 6 to 8 inches in diameter of disk when fully expanded. It is a very handsome species, when living.

Edwardsia Leidyi, sp. nov. Figures 2, side, 3, aboral end.

Edwardsia, sp. Mark, Embryol. Mon., Mem. Mus. Comp. Zoöl., ix, pl. xii, figs. 24–33, 1884 (development and structure).

Column, in expansion, very long, slender, often flattened, soft. In the oldest stages observed by me it was still without external covering, but Prof. Mark figures it in one case with a loose and imperfect coating. Tentacles, in the oldest parasitic stage seen by me, eight short, obtuse; in a later stage sixteen have been observed and figured by Prof. Mark. Mesenteries eight, in the largest specimens studied.

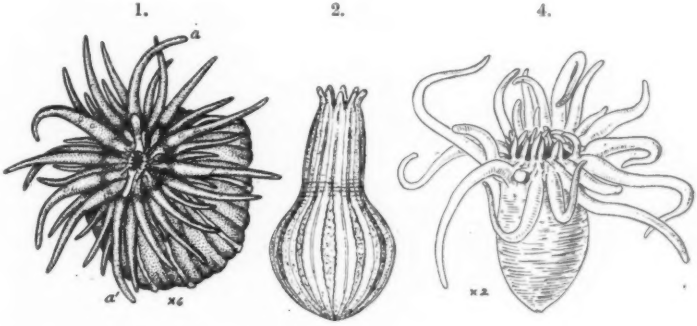
Color of column whitish, flesh-color, or pale rose, translucent, with eight longitudinal stripes of white or pale salmon-color.

Length while parasitic, in extension, up to 1 inch or more (20 to 30^{mm}), diameter ·5 to 1·5^{mm}.

The young, in various stages of growth, are frequently found as parasites in the interior of a common ctenophorus jelly-fish (*Mnemiopsis Leidyi* Ag.) on the southern coast of New England. It is common at Wood's Holl, Mass., and Newport, R. I. Several specimens of different ages are often found together.

The completely developed state of this species is probably unknown. Prof. Mark has figured a free stage, presumably raised from the parasite, with sixteen tentacles, in two unequal cycles, and with a rudimentary mucous sheath. The latest stages raised by me from the parasite had but eight tentacles and did not form a sheath, though it was then considerably longer than the young of *E. lineata* V. having 18 tentacles. Hence I do not think it can be the young of the latter, as Prof. Mark suggested. Moreover, its colors are entirely different and the tentacles are much shorter and more obtuse. It is more likely to be related to *E. pallida* V. than to any of the other known species. It resembles some of the European species that are also parasitic in jelly-fishes, while young. It is very contractile and is protean in form.

This parasite was first noticed by Mr. A. Agassiz in 1865, North Amer. Acal., p. 23, but he did not recognize it, at that time, as an actinian. I have a good series of drawings of it made in 1881–1883, showing its generic characters. Figs. 2 and 3 are by J. M. Blake, from life.



Dactylactis viridis, sp. nov. Figures 4, 5, 6.

A free-swimming cerianthid found in the Gulf Stream.

Column smooth, very changeable in shape, usually about twice as long as broad, in life; sometimes pear-shaped with the basal region swollen and rounded at the end; sometimes top-shaped, with the basal end pointed; sometimes most swollen in the middle. Usually there are no flutings, when expanded, but in some cases, when the base is swollen, it shows slight invections. The margin is plain and simple, tentaculate; there appears to be a terminal pore.

Outer tentacles, in the largest two observed, 18 and 20, in a single circle, only slightly unequal in length and size, long, slender, regularly tapered, usually longer than twice the diam-

eter of the body, sometimes nearly thrice as long, in living specimens. Oral tentacles nearly equal in number to the outer ones, varying in length from one-fourth to one-half the length of the latter, smaller and more delicate, tapered, carried erect, or nearly so, while the outer tentacles are widely divergent or often recurved and bent in various directions.

Color in life, light olive-green; tentacles translucent pale greenish.

Length of column about ·5 inch (10 to 12^{mm}); diameter about ·25 inch (5 to 7^{mm}); length of longest tentacles about 14^{mm}.

Taken several times by the "Albatross." Among other places, at sta. 2587, N. lat. 39° 02′, W. long. 72° 38′; sta. 2749, N. lat. 39° 42′, W. long. 71° 17′, Sept. 19, 1887; surface temperatures 71° and 67° F.

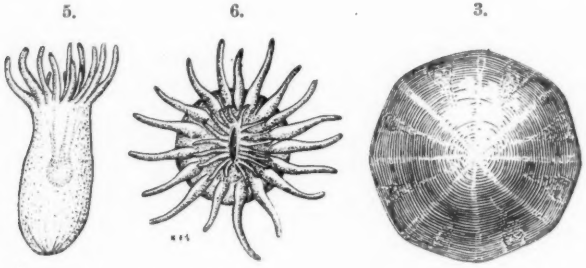


Fig. 4 is by J. M. Blake; figs. 5, 6, by A. H. Baldwin, both from life.

This species somewhat resembles *D. digitata* Van Beneden, taken near Bermuda (Plankton Exp. Anthozoa, p. 94, pl. vii, figs. 19–22, 1898), but the latter is much smaller, column 6·42^{mm} long in preserved specimens, and had 14 marginal and 10 oral tentacles. Possibly it may be a younger state of the same species. It will need specimens intermediate in size to determine this. It is probably immature.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Hyponitrous acid and Hyponitrites.*—According to Kirschner's investigations, the hyponitrites may be prepared readily from potassium oxyimidosulphonate. Fifty grams of this salt is dissolved in 35^{cc} of boiling water. After cooling by means of ice, the solution is mixed with 10^{cc} of a concentrated sodium hydrate solution (1 : 1), the temperature of the mixture not being allowed to rise above 30°. After cooling to 10°, 90^{cc} more of the sodium hydrate solution are added, the mixture is heated to 50° for half to three-quarters of an hour, and is then poured into a liter of water. This solution contains sulphate, sulphite and hyponitrite of sodium and also a little undecomposed oxyamido-salt and some hydroxylamine. By adding yellow mercuric oxide, these last substances are destroyed. The liquid, after filtering, is made up to four liters and silver nitrate is added so long as a light yellow precipitate, consisting of silver hyponitrite, is produced. By the addition of barium, strontium or calcium nitrate to a strongly alkaline solution of silver hyponitrite, a precipitate is obtained of the corresponding hyponitrite. It is washed with alcohol and ether and dried on filter paper. All of these salts are slightly soluble in water, have an alkaline reaction and evolve nitrous oxide with acids. The calcium salt is the most stable. It loses its crystal water with difficulty and is not affected at the ordinary temperature by carbon dioxide. They are represented by the formulas $Ba(NO)_2 . (H_2O)_4$, $Sr(NO)_2 . (H_2O)_6$ and $Ca(NO)_2 . (H_2O)_4$ respectively. On adding lead acetate to the sodium salt in alkaline solution, a yellowish-white precipitate of basic lead hyponitrite is produced; which on treatment with acetic acid yields the normal salt $Pb(NO)_2$, as a yellow crystalline powder, which explodes on heating. Copper sulphate added to sodium hyponitrite gives, on treatment with ammonia, a green amorphous powder having the composition $Cu(NO)_2 . Cu(OH)_2$. Silver hyponitrite $Ag_2(NO)_2$ is obtained in crystals from a strong ammonia solution. It is decomposed by hydrogen chloride, yielding hyponitrous acid. The free acid does not decolorize an iodine solution nor does it set free iodine from potassium iodide. Bromine oxidizes it to nitric acid, though the reaction is not a quantitative one.—*Zeitschr. anorg. Chem.*, xvi, 424–437, 1898. G. F. B.

2. *On Experiments with Helium.*—It has been shown by Travers that when an electric discharge is passed through a Plücker tube containing helium at a pressure of about three millimeters, the electrodes being of platinum, a reddish-yellow glow at first appears, which, passing through shades of yellow and green, finally becomes the phosphorescent glow characteristic of a vacuum. Evidently these changes are due to the gradual absorption of the helium by the platinum which has been deposited by

means of the spark on the walls of the tube; since on heating, the helium is again liberated and the colors successively appear in the inverse order. The best defined line, obtained when the green glow is most intense, has the wave length 5015·6. And if now the still remaining gas is removed, and the tube is gently heated, the absorbed gas is set free and the greenish glow reappears. It would appear therefore that the glow is not due to the last absorbed portion of helium, but comes solely from the lowering of the pressure arising from the absorption. Moreover, the author finds that while hydrogen, nitrogen and gaseous carbon compounds, like helium, are more or less readily absorbed when sparked in presence of platinum electrodes, argon is taken up only in very small amount. And he has taken advantage of this fact to separate helium from argon; the process succeeding when only 2 per cent of helium is present. By means of a Sprengel pump, a mixture of these gases is kept in circulation at 3^{mm} pressure, through a Plücker tube kept cool by a water jacket, for six hours. And now, on removing the residual gas, and heating the tube, the helium which is obtained contains only a trace of argon.—*Proc. Roy. Soc.*, lx, 449–453, 1897. G. F. B.

3. *On Calcium nitride.*—The recent noteworthy address of Sir Wm. Crookes as President of the British Association has given increased interest to every proposed process for rendering the nitrogen of the atmosphere available in agriculture. A purely chemical process of this sort has now been proposed by Moissan in connection with his production of metallic calcium.* In contact with nitrogen at the ordinary temperature, calcium undergoes no change. But as the temperature is raised, the metal changes from white to yellow, until, at a low red heat, it takes fire and burns in the nitrogen, absorbing it with great rapidity, and giving a bronze-colored nitride. The best result is obtained by placing the calcium in a boat of nickel, placed within a tube of the same metal, through which is sent a current of pure and dry nitrogen. Under the microscope, calcium nitride appears in the form of small transparent crystals yellowish-brown in color, having a density of 2·63 at 17°, and fusing at 1200° approximately. Heated in hydrogen to redness, ammonia is evolved with production of hydride. Chlorine decomposes it with incandescence giving the chloride. It burns in the air, and in oxygen, even below a red heat. Mixed with carbon and heated to 800° calcium nitride suffers no change. But in the electric furnace it is converted into calcium carbide. If the mixture be heated to 1200°, a small quantity of cyanide is produced. Heated to bright redness in a current of nitrogen dioxide, it is converted with incandescence into calcium oxide and nitrogen. In the absence of water, acids have no action on the nitride. Anhydrous alcohol gives calcium ethylate and ammonia. Thrown into water, it decomposes it with effervescence, producing ammonia and calcium

* This Journal, IV, vi, 428, November, 1898.

hydrate. Its composition was determined (1) by weighing the boat before and after converting the calcium into nitride; and (2) by decomposing a weighed quantity of the nitride with water. Four experiments gave 18·37, 18·21, 18·81 and 18·17 per cent of nitrogen and 81·63, 81·79, 81·19 and 80·49 of calcium; the formula Ca_3N_2 requiring 18·92 of N and 81·08 of Ca. The author thinks that the production of calcium nitride industrially will solve the problem of the manufacture of ammonia from the atmosphere.—*C. R.*, cxxvii, 497–501, October, 1898. G. F. B.

4. *On Sodium sub-oxide and peroxide produced by combustion.*—The composition and the heat of formation of the sodium oxides produced by combustion has been studied by FORCRAND. About 20 grams of sodium was melted in a tubulated glass retort, provided with a spherical condenser, also tubulated; a current of dry air, free from carbon dioxide, being passed through the apparatus. A little above its fusing point the sodium became covered with a gray layer, which soon increased to form voluminous arborescent gray masses. If the operation be continued the gray mass takes fire, producing white vapors, which condense both in the retort and the receiver, leaving a yellowish porous mass which becomes nearly white on cooling. The three products were then analyzed. The gray mass gave 81·88 per cent of sodium and 0·1512 gram evolved 22·05^{cc} of hydrogen when placed in water; whence it was composed of 96·26 per cent of the sub-oxide Na_2O mixed with 3·74 per cent of sodium. The white snow condensed in the cooled receiver gave 58·13 per cent of sodium, corresponding to the formula Na_2O_2, which requires 58·97. The white powder in the retort was also Na_2O_2, with a trace of moisture. The yellowish-white residue gave 64·24 and 60·18 per cent of sodium in two samples; and hence was a mixture in variable proportions of Na_2O and Na_2O_2. Heated again in a current of dry air, it was converted into Na_2O_2 with a trace of moisture. No trioxide Na_2O_3 apparently was formed in this reaction.

In a subsequent paper, the author gives the results of his experiments to determine the heat of formation of these oxides. He finds for the sub-oxide Na_2O, the following equation:

$$Na_2 \text{ solid} + O \text{ gas} = Na_2O \text{ solid} + 101{\cdot}57 \text{ cal.}$$

For the dioxide, Na_2O_2

$$Na_2 \text{ solid} + O_2 \text{ gas} = Na_2O_2 \text{ solid} + 119{\cdot}79 \text{ cal.}$$

And for the oxide Na_2O

$$Na_2 \text{ solid} + O \text{ gas} = Na_2O \text{ solid} + 100{\cdot}40 \text{ cal.}$$

—*C. R.*, cxxvii, 364–366, 514–516, August, October, 1898.

G. F. B.

5. *On Aluminum nitride.*—It has been pointed out by FRANCK that aluminum nitride is obtained when an intimate mixture of finely divided aluminum and calcium carbide is heated in a porcelain crucible by means of a blast, with free access of air. The product contains 15 to 20 per cent of nitrogen. Moist air decom-

poses it slowly, boiling water more rapidly, and alkalies very readily, with production of ammonia. A better yield is obtained by passing nitrogen over a mixture of aluminum and dry calcium hydrate.—*J. Chem. Soc.*, lxxiv, ii, 377, August, 1898. G. F. B.

6. *On Enantiomorphism.*—As is well known, enantiomorphous substances are divisible into two classes, intermolecular and intramolecular; i. e., those in which this property is determined by the arrangement of the molecules, and those in which it is determined by their structure. The first class, to which belong quartz and sodium chlorate, are not optically active in solution, though their crystals rotate the plane of polarization. The second class, to which belong all compounds containing an asymmetric carbon atom, are active in the amorphous or liquid state as well as when crystallized. But while the latter must invariably give crystals which are either right-handed or left-handed, there appears no reason why the former should give crystals of the one sort in preference to those of the other. KIPPING and POPE have studied the crystals of sodium chlorate deposited from pure aqueous solutions to ascertain whether the ratio of dextro- to lævo-sodium chlorate is in fact unity. About 200^{cc} of a saturated solution of this salt was placed in a shallow glass crystallizing dish and allowed to evaporate spontaneously. Each crystal developed apart from its fellows as a right-angled prism; and when they were about 5^{mm} on a side, they were removed from the liquid and the sign of the circular polarization was determined by examination in a polarizing microscope with an inch objective. If the analyzer had to be turned to the right to give extinction, the crystal was dextro-rotatory; and *vice versa*. In only two cases out of 46 crystallizations were equal numbers of dextro- and lævo-rotatory crystals deposited. But the mean percentage value in all the 46 experiments gave 50·83 of dextro crystals; while the weighted mean, in which allowance is made for the total number of crystals obtained, gave 50·08, with a probable error of 0·11. It appears therefore that on allowing sodium chlorate to crystallize spontaneously from pure aqueous solutions, equal numbers of the enantiomorphously related crystals, on the average, are deposited. The authors then took up the question whether, if the crystallizing sodium chlorate solution contained an enantiomorphous substance of the second class, i. e., containing an asymmetric carbon atom, such as dextroglucose for example, there would be the same tendency, aside from the solubility, for dextro- as for lævo-sodium chlorate to crystallize. For this purpose they used solutions containing dextrose, mannitol and dulcitol and found the weighted means to be 31·75, 40·55 and 51·27 respectively. Whence they conclude that on crystallizing a substance which is not enantiomorphous in the amorphous state in presence of one which is so, the average ratio of the crystals of each sort deposited may be made to differ from unity.—*J. Chem. Soc.*, lxxiii, 606–617, August, 1898. G. F. B.

7. *The Doctrine of Energy; a Theory of Reality.* By B. L. L. 12mo, pp. x, 108. London, 1898 (Kegan Paul, Trench, Trübner & Co.).—An argument in favor of dropping Matter as an entity and making Energy the sole basis of Metaphysics. It appears to us quite inconclusive. G. F. B.

8. *Gravitation constant and mean density of the earth.*—The experiments on this subject begun in Spandau in 1884, at the expense of the Königliche Akademie der Wissenschaften and with the aid of the German government, have now been brought to a conclusion. The complete account of the work appears in the proceedings of the K. Akad. d. Wissenchaften of Berlin. The method consisted in double weighing in two scale pans, separated by a connection 226^{cm} long. The authors, F. Richarz and O. Krigar-Menzel, give as their first result

$$\triangle = (5{\cdot}505 \pm 0{\cdot}009)\ \frac{g}{cm^3}$$

The results obtained by previous observers are as follows:

Observer.	Method.	$\triangle$	Prob. Error.
Cavendish	Torsion balance	5·45	
Reich	"	5·49—5·58	
Baily	"	5·67	
Cornu and Baille	"	5·56 5·50	
Ph. v. Jolly	Balance with long supports	5·692	±0·068
J. Wilsing	Pendulum apparatus	5·594	±0·032
"	Pendulum apparatus	5·577	±0·013
J. H. Poynting	Balance	5·4934	
C. V. Boys	Improved torsion balance	5·5270	

The German investigators F. Richarz and O. Krigar-Menzel believe that of the above the results of Wilsing, Poynting and Boys are the most accurate. Under certain assumptions Poynting's final result would have a less probable error than that of the authors. Boys estimates that his best result has a probable error of ±0·002. The probable error of Richarz and Menzel is 1·6 per thousand.— *Wied. Ann.*, No. 10, 1898, 177–193. J. T.

9. *Theory of the Coherer.*—The experiments on wireless telegraphy have turned the attention of many investigators to the obscure phenomena of the coherer. E. Aschkinass reviews the theories of Branly, Lodge, Auerbach, Arons, D. van Gulik and others, and points out that sufficient attention has not been paid to the increased resistance of the coherer, due to electric waves. Wireless telegraphy depends upon the diminished resistance which allows a relay circuit to pass through the coherer. The author describes many experiments which apparently contradict the theory of Lodge and others that the increased conductivity is due to minute sparks, which bridge over the discontinuity

in the relay circuit. He points out the effect of heat on the coherer and shows that even the heat of the hand can influence its sensitiveness. The heat developed by the electric waves therefore under certain conditions may lead to an increased resistance in the coherer. This development of heat might arise from a definite potential-difference in the formation of stationary electric waves. The author believes that we could gain more insight into the more or less mysterious working of the coherer if we knew more about the conditions of the conduction of electricity in metals. Possibly electrolytic action analogous to that which takes place in electrical discharges through gases in which the motion of ions is involved may in time explain the phenomena of the coherer.—*Wied. Ann.*, No. 10, 1898, pp. 284–307. J. T.

10. *Theory of the Hall effect in an Electrolyte.*—Roiti, Journal de Physique, 1883, failed to find any Hall effect in a liquid. Recently Bagard (Comptes Rendus, vol. cxxii and vol. cxxiii, 1896) claims to have observed an effect. This is denied by Florio (Nuovo Cimento [4], vol. iv, 1896). Dr. F. G. Donnan calculates that in order to detect the effect a difference of potential of the order of 10,000 volts and a very powerful magnetic field would be necessary.—*Phil. Mag.*, Nov. 1898, pp. 465–472. J. T.

Dr. Hall, in recent experiments in the Jefferson Physical Laboratory, has failed to confirm Bagard results and points out the disturbing effects of convection currents in the electrolyte arising in a magnetic field. J. T.

11. *The Free Expansion of Gases.* Memoirs by Gay-Lussac, Joule and Joule and Thomson. Translated and edited by J. S. Ames, Ph.D.; pp. 106. New York, 1898 (Harper & Brothers).—The inauguration of the series of *Harper's Scientific Memoirs* under the editorship of Professor J. S. Ames was announced in our August number. The first volume of the Series has now appeared and shows definitely the details of the plan. As before stated, it is somewhat analogous to the Ostwald series of scientific classics published in Germany. The single volume, however, is not confined to a paper by one author, but a series on a given subject are brought together. For example, the present volume, on the Free Expansion of Gases, opens with Gay-Lussac's memoir of 1806; an early paper by Joule (1845) follows, and then subsequent papers by Thomson and Joule (1853–1862). This bringing together of a number of memoirs on a given subject is an admirable plan, and serves to give a considerable degree of completeness to the discussion of the topic in question.

Further, the editor has added a brief biographical sketch of the authors included, with a statement of their most important scientific researches; also at the close, a list of books of reference and of other articles dealing with the same topics, and finally an index.

The titles are now announced of the subjects which are to be covered by nine other volumes of the Series; thus volume II includes Fraunhofer's Papers on Prismatic and Diffraction Spec-

tra; volume III gives memoirs on Röntgen Rays, etc. The continuation of the Series is stated to depend upon the success of these opening volumes. Of their great value to all students and workers in physics there can be no possible question, and it is heartily to be desired that the response of the public may be sufficiently prompt and generous to justify the publishers in going on with the work.

II. Geology and Mineralogy.

1. *The Geological History of the Isthmus of Panama and Portions of Costa Rica.* Based upon a reconnaissance made for Alexander Agassiz; by Robert T. Hill, with special determinations by William H. Dall, R. M. Bagg, T. W. Vaughan, J. E. Wolff, H. W. Turner, and Ahe Sjogren, with nineteen plates. Bulletin of the Museum of Comparative Zoology at Harvard College, vol. xxviii, No. 5 (Geological Series, vol. iii), Cambridge, Mass., June, 1898.—This work of 285 pages, with nineteen plates and twenty-four figures, only claims to be a reconnaissance, yet it is a very thorough summary of the known geomorphology, geology and paleontology of the Isthmian and Central American regions, dealing with those problems which pertain to the union of the continents and the existence of pre-historic Isthmian straits. It is based upon two transcontinental sections, one of which was made across the Isthmus of Panama and the other across the Republic of Costa Rica, to which is also added the results of the late W. M. Gabb's explorations in Talamanca, about midway between the two sections explored by Mr. Hill.

Part I of the work deals with the geographic position of the Isthmian region, showing the independent position of the North, Central and South American orogenic systems; the physical differences between the lands surrounding the Caribbean and the Gulf of Mexico, the distinction of the present volcanic regions from those of volcanic quiescence and the relation of the volcanic mountains to the areas composed of folded sedimentaries.

The geomorphology of the Isthmus of Panama is dealt with at length, showing that this barrier between the oceans is an old degraded land cut up into numerous summits and void of a well-defined axial backbone. Its topography is contrasted with that of the higher Andean region to the south and the Costa Rican plateau to the north. A summary of the topographic evidence shows the relative antiquity of the Isthmian land and that it is a remnant of a much wider area, the former seaward extensions of which in the now submerged marginal platforms are well shown upon profiles and maps.

Part II treats of the geology of the continental section across the Isthmus of Panama, giving in minute detail every feature of the brief 40 miles which there separate the two oceans. All the rocks are described, beginning with the low recently elevated coral reefs on the Atlantic side. The coast of both sides is

indented by swamp levels, which for a distance at least from either sea are filled with formations containing Pleistocene sea shells. These are cut out of a matrix of greatly deformed Oligocene and Eocene rocks. Below and contemporaneous with the Eocene rock is a great series of igneous rocks, the latest of which is found interbedded with the Eocene Tertiary. These consist of tuffs of augite-porphyrite, olivine-basalt, trachyte, dolerite, andesitic lava and rhyolitic pumice. A summary of the geological evidence shows that the Isthmian barrier was closed at the close of the Oligocene and has since remained land.

Part III treats of the Pacific coast from Panama westward to Punta Arenas, Costa Rica, showing characteristic elements of the coast, including the wave-cut bluffs and elevated base-level plains which, found upon both the islands and the main land, show that the former are remnants which have been severed from the latter.

Part IV deals with a continental section across Costa Rica from Punta Arenas through San Jose to Port Limon. This describes the geomorphology and geology of this interesting section of 115 miles across the high volcanic plateau of Central America, which here rises to an elevation of nearly 11,500 feet. It is shown that several well-defined base-leveled marginal plains occur on both the Pacific and Atlantic sides of the continent as in Panama. Much information is given upon the great volcanic piles which rise above the sedimentaries of the lower coastal region, which represent vast accumulations of volcanic debris since Tertiary time. Attention is called to the line of interior basins in which the chief centers of population and agriculture are segregated, at altitudes of from 4000 to 5000 feet. A fine illustration is given of the crater of Turrialba volcano, the most eastern of the four great volcanoes along this section. A section is also given from the summit of this eminence to the Caribbean border which lies only a short distance from its eastern shore, the details of which give much new information concerning the character of the folded Tertiary sedimentaries and their interbedding with old volcanic extrusive lava.

At Gualava, altitude 1400 feet, there are disturbed sedimentaries containing interesting fossils of the Vicksburg formation as determined by Dr. Dall, which constitute the most southern known outcrop of rocks of that epoch. In this section the volcanic rocks also contain the interesting species theralite, which was recently noted by Prof. J. E. Wolff in this Journal. In the basin valley of San Jose, about 5000 feet above the sea, ancient looking limestones were found which were largely composed of Foraminifera, Rudistes, shells of Inocerami and mollusca which very much resemble certain formations of the Great Antilles adjacent to the close of the Cretaceous and beginning of the Eocene Tertiary. The occurrence of true granite at Siquires is noted as well as the fact that granitic debris is found in the oldest sedimentary rocks, indicating the existence of a pre-Tertiary granitic plexus in this region. The interesting base-leveled, submerged, veneered and reëlevated coastal plains of Port Limon are also described.

A comparison of the Panama and Costa Rica sections is then given, together with an interesting tabular summary, page 236, of the known formations and events.

In working out the great amount of original data concerning the detailed geology of these hitherto little known regions, the author was assisted by the minute studies of several specialists whose reports are of greatest value, among which may be mentioned the reports of Dr. W. H. Dall on the Tertiary mollusca; Prof. R. M. Bagg on the Foraminifera; Prof. J. E. Wolff on the igneous rocks; Mr. H. W. Turner, who made valuable microscopic studies of certain peculiar and difficult earths of volcanic origin; Mr. Ahe Sjogren, and Mr. T. Wayland Vaughan. The special reports by these authorities are published as appendices to the work and are each valuable contributions which should be separately noticed.

Having secured in personal study and observation a foundation for making deductions, the author in Part V discusses the "Union of the Continents and the Problems of the Straits," setting forth a résumé of the geology of the Central American mainland, showing the present condition of knowledge thereof so far as the incompleteness of exploration will permit. A concise résumé is made of the entire geologic sequence. Interesting facts are presented indicating the existence of a granitic basement, which show that there is room in this belt alone for much study. Attention is called to the burial of the Paleozoic rocks between the southern boundary of the United States and the equatorial South America by the vast accumulations of the Mesozoic sedimentaries in Mexico and by volcanic and Tertiary material in Central America, the only outcrops of fossiliferous Paleozoic rocks known between these regions being the Carboniferous strata of Guatemala and Chiapas as described by Dr. Sapper.

The Pre-Cretaceous Mesozoic seems to be as problematical in these tropical regions as it is in the United States. The writer, however, calls attention to localities in Mexico and Guatemala which have striking stratigraphic analogy to the Red Beds of the western interior region of our own country.

A chapter on diastrophism and vulcanism deals with interesting facts of orogenic history, the most important of which is orogenic revolution of late Tertiary time, which, according to Mr. Hill, seems to have been the dominating factor in producing the present conspicuous features of Central American and Antillean geography, and to have been instrumental in producing the great east and west corrugations and troughs of the American Mediterranean which have been described by others as the river valleys of submerged continents.

The evidence of former periods of marine connection in the Isthmian region is dealt with *in extenso*. The conclusion is reached that there is some evidence that a land barrier severed the two oceans as far back in geologic history as Jurassic time and that this barrier may have continued through the Cretaceous

period. No evidence is presented or obtainable to show that this barrier was the present Isthmian region, however. The pale ontologic evidence indicates clearly the existence of an ephemeral passage at the close of the Eocene period which was closed near the end of the Oligocene, and there is no evidence of Miocene, Pliocene, Pleistocene or recent connection in the Isthmian section.

The conception, carrying out, and publication of this valuable memoir is due to the munificence of Professor Alexander Agassiz. We are informed that he has in hand the manuscript of another and larger report by Mr. Hill upon the detailed geology of the Island of Jamaica, a type study of the Antillean geology which will deal further with the problems of the origin of the tropical American lands.

2. *Geology and Mineral Resources of the Judith Mountains of Montana;* by W. H. Weed and L. V. Pirsson. From the Eighteenth Annual Report of the Director of the U. S. Geological Survey, Washington, 1898.—This paper is a very interesting discussion of the geological history and mineral resources of the Judith Mountain region in Central Montana. The Judith Mountains form an independent group of elevations of limited extent, rising at the highest point 6386 feet above the sea, or nearly 3000 feet above the surrounding plain. Like other similar districts in the northwest, the isolated position of the group, surrounded as it is by a broad expanse of Cretaceous rocks, has given rise to many interesting geological problems, for the working out of which the conditions are peculiarly favorable. Perhaps the most interesting point brought out in the present memoir is the laccolithic character of the igneous intrusions which make up a large part of the mountains. This subject is very fully treated by Pirsson, with numerous illustrations, and the author proposes to discuss it in an early number of this Journal. The character of the igneous rocks is given in the following summary:

"The igneous rocks of the Judith Mountains are of acid-feldspathic character, and are very like those characteristic of other laccolithic areas. They comprise granite-porphyry, syenite, syenite-porphyry, and diorite-porphyry in the main masses, with dikes and sheets of the variety of phonolite-porphyry called tinguaite-porphyry. While the intrusion of the former rocks has taken place according to well-known processes, it is believed that the phonolite-porphyry was formed by some process of differentiation in the main masses and was injected into the sediments above them by what may be called secondary intrusion. The granularity of the rocks depends on their chemical composition and not on the depth at which they have been intruded."

As regards the sedimentary rocks, which are most extensively and regularly developed in the western part, the characteristic thick-bedded limestones of Carboniferous age cover much the larger part of the area. Between these and the Cretaceous of the plains (Dakota and Benton) are parallel bands belonging to the Lower Cretaceous (Kootanie) and to the Jurassic (shales,

thin-bedded limestones and sandstones). Within the Carboniferous area and often involved here in the igneous outflows are limited areas of Siluro-Devonian and of Cambrian. The relations of these strata to each other and to the igneous rocks are well shown in the colored geological map, as also in the many excellent sections. The discussion by Weed of these rocks and of the successive orographic movements in which they have been involved is highly interesting, but it is impossible to attempt to summarize it here. The final chapter is devoted to the ore deposits and coal of the region.

3. *Fossil Medusæ;* by CHARLES D. WALCOTT. U. S. Geol. Survey Monograph, vol. xxx, pp. 1–201, figs. 1–26, plates i–xlvii. Washington, 1898.—Beginning with the study of some obscure siliceous nodules from the Coosa shales of Middle Cambrian age from Alabama, Mr. Walcott has produced, in this monograph, an example of the highest results of modern science in the interpretation of fossil remains. It is sufficiently remarkable that any reliable evidence of the existence of these jelly-like organisms existed in Paleozoic time; but the description and illustration of both the form and internal structure of fossil Cambrian Medusæ with some two hundred and fifty figures of specimens selected from over 9000 examples could scarcely be imagined were it not a fact.

The Cambrian forms are referred by the author to a new family, Brooksellidæ, of the suborder Discomedusæ. The genus *Brooksella* is represented by two species, and *Laotira* by one species, all from the Middle Cambrian. The genus *Dactyloidites* Hall, with one species, from the Lower Cambrian of New York, is referred to the same family, Other Medusæ, originally described by Torrell and Linnarsson from the Lower Cambrian, are referred to the genus *Medusina*, a name proposed to include all species of fossil Medusæ whose generic characters cannot be determined. Under the name *Eophyton*, a number of markings, which have been supposed by many writers to be remains of plants, are figured and their probable origin as trails of floating algæ or in some cases of the tentacles of Medusæ is discussed. Descriptions and figures of the known fossil Medusæ from the Jurassic and Permian of Bohemia and Saxony are also given, and together with the original description of the Coosa material form an important monograph of the present knowledge of this group. The illustrations are numerous both in text and plates and illustrate the subject with a fullness never before attained. H. S. W.

4. *The Cretaceous Foraminifera of New Jersey;* by RUFUS M. BAGG, Jr.; pp. 1–89, plates i–vi, U. S. Geol. Survey, Bulletin 88. Washington, 1898.—This bulletin contains a description of over a hundred species of foraminifera from the Matawan, Monmouth, Rancocas and Manasquan formations of the Upper Cretaceous. A Bibliography is appended. H. S. W.

5. *Some Lava-flows of the western slope of the Sierra Nevada, California;* by F. LESLIE RANSOME; pp. 1–74, plates i–xi, U. S.

Geol. Survey, Bulletin 89. Washington, 1898.—In this paper are described a series of superimposed flows, associated with the Neocene andesite tuff, of the western slope of the Sierra Nevada, situated along the course of the Stanislaus River, which are said to stand chemically between typical andesites and typical trachytes and for convenience are called "latite" by the author to distinguish them from the ordinary clastic andesites abundant in the same fold. See this Journal, v, 355. H. S. W.

6. *Bibliography and Index of North American Geology, Paleontology, Petrology and Mineralogy for 1896;* by F. B. WEEKS; pp. 1–152, U. S. Geol. Survey Bulletin, 149. Washington, 1898.—A valuable feature of these Bibliographies, which are annually prepared by the Survey, is the classified index which enables the student to find at a glance the new matter of any particular kind distributed in the numerous publications of the year. H. S. W.

7. *Report on the Geology of Southwest Nova Scotia,* etc.; by L. W. BAILEY. Geol. Survey of Canada, Ann. Rept., vol. ix, Part M, pp. 1–154, plates i–v, and colored geological map of the region. Ottawa, 1898.—This report embraces the results of several years investigations by the author in the western counties (Annapolis, Queens, Digby, Yarmouth and Shelburne) of Nova Scotia.

The formations are the (1) Central granite axis.

(2) Quartzite and slates like the gold-bearing rocks of Halifax, without fossils but believed to be of Cambrian age.

(3) Micaceous, hornblendic and staurolitic strata, supposed to be metamorphic equivalents of Cambrian rocks.

(4) Fossiliferous slates and iron ores, of Oriskany or Eo-Devonian age.

(5) Red sandstones of Post-Carboniferous age, and believed to be of Triassic age.

And (6) Trap associated with No. 5.

The Silurian and Devonian rocks of the Nictaux-Torbrook basin and of Clementsport and the Bear River basin are fully described, and additions, of both fossil localities and species, are made to what has already been reported by Sir William Dawson and others regarding these eastern Paleozoic faunas. Particulars are given regarding the present state of development of the gold districts of Queens aad Yarmouth Counties. H. S. W.

8. *Report on a traverse of the northern part of the Labrador Peninsula from Richmond Gulf to Ungava Bay;* by A. P. LOW. Geol. Surv. of Canada, Ann. Rept, vol. ix, Part L, pp. 1–43, plates i–iv. Ottawa, 1898.—This reconnaissance survey is valuable in revealing the geographical as well as the geological features of this little known region. The rocks are chiefly ancient crystallines, metamorphic schists, eruptives, and stratified dolomites and arkoses, reported as of Cambrian age. H. S. W.

9. *Report on the Geology of the French River Sheet;* by ROBERT BELL. Geol. Survey of Canada, Ann. Rept., vol. ix, Part I, pp. 1–29, and geological colored map. Ottawa, 1898.—

This is a condensed report of the investigations in this region by the author and other members of the Survey covering several years. The map is on the scale of 4 miles to 1 inch; and the formations represented include Laurentian, Huronian, Cambro-Silurian and Silurian of Niagara-Clinton age. H. S. W.

10. *Le Granite des Pyrénées et ses phenoménes de contact;* by A. LACROIX (Bull. des serv. carte géol. de France, No. 64, pp. 68, pl. 3, 1898).—In this interesting work Professor Lacroix confines himself to discussing the details of observation on the contacts in the vicinity of Haute Arriége. The facts, which are given in considerable detail, lead him to believe that where the granite has come in contact with schists, these latter have been enriched in feldspar by transference of material from the granite and converted largely into gneisses; where calcareous rocks have been altered, it has been of the more usual type already well known and previously described with formation of various lime-bearing silicates. The endomorphic modification suffered by the granite when in contact with the calcareous beds, is its transformation into basic types, generally diorite, sometimes norite and even peridotite in border zones at the contact. This is believed to be caused by enrichment in basic oxides due to the melting up and absorption of masses of the calcareous beds. Attention is also drawn to the importance of mineralizing gases and vapors in the contact area, which the author thinks have not been sufficiently taken into account by previous investigators. He thinks that the action produced by deeply buried granite magmas is of quite different character from that effected by those more nearly approaching the surface, as those for instance in the Christiania region.

L. V. P.

11. *Igneous Rocks of Tasmania;* by W. H. TWELVETREES and W. F. PETTERD. (Trans. Australasian Inst. Min. Eng., vol. v, No. 62, 1898.)—Although this account is very short and confined mostly to general statement, it is none the less welcome in giving petrographers some notion of the rocks occurring in a hitherto little known region. Granites, felsites, augite-syenite, trachyte andesites, gabbro, basalt, diabase, limburgite, minette and peridotites are among the various types briefly mentioned. L. V. P.

12. *On Sulphohalite.*—In the course of a series of investigations of the phenomena of salt-bed formation, J. H. van't Hoff and A. P. Saunders attempted to obtain an artificial salt corresponding to the composition, $3Na_2SO_4.2NaCl$, given by Hidden and Machintosh for sulphohalite. With this end in view solutions containing sodium chloride and sodium sulphate were evaporated at the extreme temperatures of 25° and 70° centigrade. In the presence of a sufficient quantity of sodium chloride, the sulphate crystallized out, even at the lower of these temperatures, without water of crystallization, i. e. as thenardite. Thus, at both 25° and 70° the authors obtained well-formed cubes of sodium chloride, free from sulphate, and rhombic pyramids of thenardite free from chlorine. The double salt, however, was not formed, though its

formation was to have been expected under these circumstances. The authors also attempted to analyze the original mineral, but two independent specimens obtained from the same dealer proved to be chemically *sodium chloride* while their specific gravity was only 2·16, that given for sulphohalite being 2·489.

The authors conclude, on the grounds stated, that for the purposes of their investigations they are not called upon to take such a double salt as $3Na_2SO_4 . 2NaCl$ into consideration. Furthermore, they add that "the existence of sulphohalite appears at least doubtful," a conclusion which hardly seems justified.*—*Sitzungsberichte d. K. Akad., Berlin*, 1898.

III. Miscellaneous Scientific Intelligence.

1. *National Academy of Sciences.*—The following papers were entered for reading at the autumn meeting of the Academy, held at New Haven, Conn., Nov. 15, 16.

W. K. Brooks and L. E. Griffin: Anatomy of *Nautilus pompilius.*

C. Barus: On solid solutions of colloidal glass.

Charles S. Minot: Three phases of vertebrate development. Notes on mammalian embryology.

R. H. Chittenden: The influence of alcohol and alcoholic fluids on digestion.

Lafayette B. Mendel: On the conditions modifying the excretion of kynuremic acid.

W. S. Eichelberger: Perturbations of Minerva, with a preliminary determination of its orbit.

O. C. Marsh: On a series of native skulls from New Guinea On the reputed prefrontal bones in recent mammals. On the brecciated fossil marble from Kishiu, Japan. On some rare antiquities from Mexico.

F. A. Gooch and Louis Cleveland Jones: Sodium tungstate as a retainer for boric acid.

F. A. Gooch and Martha Austin: The ammonium-magnesium phosphate of analysis.

S. L. Penfield: The chemical composition of tourmaline.

A. E. Verrill: On the nature and origin of the marine fauna of Bermuda. On the ability possessed by certain animals to recover after complete freezing.

Ira Remsen: Further researches on the two isomeric chlorides of orthosulphobenzoic acid: A study in tautomerism.

H. A. Rowland: Report upon work in spectrum analysis carried on by help of the Bache Fund.

A. A. Michelson: Observations on the Zeeman effect with the echelon-spectroscope.

Volume VIII of the Memoirs of the Academy has been recently issued; it contains a paper on the Study of the Effect of the Venom of *Crotalus Adamanteus* upon the Blood of Man and Animals, by S. Weir Mitchell, M.D., and Alonzo H. Stewart, M.D.

2. *Studies from the Yale Psychological Laboratory;* edited by Edward W. Scripture, Ph.D. Volume V, pp. 1–105, New Haven, Conn., 1898.—Another volume has been added to the series of contributions from the psychological laboratory under the charge of Dr. Scripture, thus testifying to the active spirit of

*The editor is informed that Prof. Penfield will make a new analysis upon authentic material.

research which he has developed. Among the papers here printed is to be noted particularly the research by M. Matsumoto on acoustic space. The work for this, begun at Tokyo, was chiefly carried forward in New Haven from 1896 to 1898. It is only possible to call attention to the extended series of experiments here detailed, and to quote the closing paragraph: "Our final conclusion is thus that an acoustic sensation receives its spatial form primarily from the space idea which is given to us by the visual, tactual and motor sensations. Acoustic space presupposes the existence of the space form of other sensations. We have only to give an account of how the perception of the position of sounds arises on the basis of the already existing space which was given to us by other sensations. As to the further problem of the ultimate origin of the space form of perception, its solution must be sought in the visual and tactual perception."

3. *Report on the Survey of the Boundary-Line between Alleghany and Garrett Counties;* by L. A. BAUER, chief of party; pp. 2–48, with six plates. Maryland Geological Survey, Preliminary Publication. William Bullock Clark, State Geologist, Baltimore, 1898.—This report has been recently issued, and gives an account of the work of triangulation accomplished, with also a statement of the magnetic observations made in connection with it.

4. *A Catalogue of Scientific and Technical Periodicals, 1665–1895,* together with chronological tables and a library check-list; by HENRY CARRINGTON BOLTON. Second edition, pp. vii, 1247. Washington, 1897 (Smithsonian Miscellaneous Publications, No. 1093).—This new edition of Professor Bolton's Catalogue of Scientific Periodicals has been largely increased over the earlier issue published in 1885. Some eighty-six hundred titles are included, belonging not only to the natural and physical sciences proper but also to anatomy, physiology, and veterinary science; medicine, however, is excluded. Besides the titles given in alphabetical order, with information as to volumes issued, indexes, etc., the work contains a chronological table from 1728 to 1895, showing the volumes of each journal which belong to a particular year. The value of this table for those looking up references can hardly be overestimated.

5. *Differential and Integral Calculus;* by P. A. LAMBERT, M.A., Lehigh University, pp. 245. New York and London, 1898. (The Macmillan Co. Price $1.50.)—The arrangement of topics is somewhat different from that usually followed. Differentiation and integration are treated simultaneously, which in the opinion of the author serves to economize the time and effort of the student. A certain looseness of statement is occasionally noticeable (e. g. in the definition of a limit), which detracts from the merits of other features of the book.

INDEX TO VOLUME VI.*

A

Academy, National, meeting at New Haven, 512.
Adams, J. S., Law of Mines and Mining in the U. S., 436.
Agassiz, A., Tertiary limestone reefs of Fiji, 165.
Aldous, J. C. P., Physics, 100.
Ames, J. S., Zeeman effect, 99; Free Expansion of Gases, 504.
Antillean Valleys, submarine, Spencer, 272.
Association, American, meeting at Boston, 199, 363.
British, meeting at Bristol, 372.
Austin, M., manganese as pyrophosphate, 233.

B

Barringer, D. M., Law of Mines and Mining in the U. S., 436.
Barus, C. colloidal glass, 270; compressibility of colloids, 285.
Bauer, Survey of Maryland, 513.
Beecher, C. E., origin of spines, 1,125, 249, 329.
Block Island, prehistoric fauna, Eaton, 137.
Bolton, H. C., Catalogue of Scientific Periodicals 1665–1895, 513.
Botany—
Flora of the United States and Canada, Britton and Brown, 277.
Trees, winter conditions of reserve food substances, Wilcox, 69.
Britton, N. L., Flora of the United States and Canada, 277.
Brown, A., Flora of the United States and Canada, 277.
Browning, P. E., detection of sulphides, etc., 317.
Brush, C. F., a new gas, 431.
Brush's Mineralogy revised, Penfield, 436.

C

Calculus, Lambert, 513.
Canada, Geological Reports of 1897, 434, 510.
minerals of, Hoffmann, 437.
Cathode rays, change of energy into light rays, Wiedemann, 433.
reflection, Starke, 433.
Chemical analysis, Qualitative, H. L. Wells, 269; J. S. C. Wells, 269.

Chemistry—
Air, combustion in rarefied, Benedicenti, 95.
new constituents of, Ramsay and Travers, 192, 360; Brush, 431.
Aluminum, separations by hydrochloric acid, Havens, 45.
nitride, Francke, 501.
Ammonium peroxide, Melikoff and Pissarjewski, 195.
Calcium, crystallized metallic, Moissan, 428.
hydride, Moissan, 428.
nitride, Moissan, 500.
Carbon monoxide, direct elimination, Engler and Grimm, 193.
Enantiomorphism, Kipping and Pope, 502.
Helium, argon and krypton, position in scheme of elements, Crookes, 189.
experiments with, Travers, 499.
Hydrogen, boiling point, Dewar, 361; liquefaction, Dewar, 96.
Hyponitrous acid, Kirschner, 499.
Inorganic salts, molecular mass of, Werner, 195.
Iodine, in the analyses of alkalies, etc., Walker, 455.
Krypton, Crookes, 189.
Manganese as pyrophosphate, Gooch and Austin, 233.

* This Index contains the general heads, Botany, Chemistry (incl. chem. physics), Geology, Minerals, Obituary, Rocks, and under each the titles of Articles referring thereto are mentioned.

CHEMISTRY—
Metargon, Dewar, 360, 361.
Molecular mass of solid substances, Traube, 95.
determined by the boiling point, Walker and Lumsden, 429.
Molybdenum, iodometric determination, Gooch, 168.
Neon and Metargon, Ramsay and Travers, 360.
Nickel and cobalt, separation by hydrochloric acid, Havens, 396.
Ozone, boiling point, Troost, 362.
Salts, photoelectric properties of colored, Elster and Geitel, 95.
Sodic sulphate, transition temperature, Richards, 201.
Sodium carbide, Matignon, 196.
sub-oxide and peroxide, Forcrand, 501.
Sulphides, etc., detection of, Browning and Howe, 317.
Vapor pressure of reciprocally soluble liquids, Ostwald, 93.
Coherer, theory of, Van Gulik, 433; Aschkinass, 503.
Colloids, compressibility of, Barus, 285.
Crookes, W., position of helium, argon and krypton, in scheme of elements, 189.

D

Dana, E. S., Text-Book of Mineralogy, 275.
Darton, N. H., dikes of felsophyre and basalt in Virginia, 305.

E

Eakle, A. S., erionite, 66; biotite-tinguaite dike in Essex Co., Mass., 489.
Earthquakes of the Pacific coast, Holden, 200.
Eaton, G. F., prehistoric fauna of Block Island, 137.
Electric currents excited by Röntgen rays, Winkelmann, 432.
discharge, chemical effects of silent, Berthelot, 430.
in vacuum tubes, J. E. Moore, 21.
energy by atmospheric action, Warren, 93.
furnace, fusion, Oddo, 194.
Electricity, Industrial, Graffigny-Elliot, 200.
and Magnetism, Nipher, 432.
Electrochemistry, ionic reactions, Küster, 93.
Electrolyte, theory of Hall effect in, 504.
Electrosynthesis, Mixter, 217.
Energy, Doctrine of, 503.
Entomology, Text-book of, Packard, 103.

F

Field Columbian Museum, 104.
Fiji, Tertiary limestone reefs of, Agassiz, 165.
Foote, W. M., native lead with roeblingite, Franklin Furnace, N. J., 187.
Fossils, vertebrate, for the National Museum, Marsh, 101.
See GEOLOGY.

G

Gas, a new, Brush, 431.
Gases, Free Expansion of, 504.
GEOLOGICAL REPORTS AND SURVEYS—
Canada, 1897, 434, 510.
Nova Scotia, 510.
United States, 18th annual report, Walcott, 433; Topographic Atlas, 102. Publications of, 508, 509.
GEOLOGY—
Brachiopod fauna of Rhode Island, Walcott, 327.
Calamaria of the Dresden Museum, Geinitz, 198.
Cephalopoda, fossil, of the British Museum, Crick, 198.
Ceratopsia, new species, Marsh, 92.
Cretaceous foraminifera of New Jersey, Bagg, 509.
Cycad horizons in the Rocky Mountain region, Marsh, 197.
Devonian fauna of black shale of Kentucky, Girty, 384.
Fauna, prehistoric, of Block Island, Eaton, 137.
Fossil Medusæ, Walcott, 509.
Fossils from Canada, two new, Whiteaves, 198.
use of, in determining geological age, Marsh, 483.
Geological history of Panama and Costa Rica, Hill, 435, 505.
Ichthyodectes, species of, Hay, 225.
Judith Mountains, geology, Weed and Pirsson, 508.
Jurassic formation on Atlantic coast, Marsh, 105.
Loess, eolian origin of, Keyes, 299.
Mammals, origin of, Marsh, 406.
Metamorphism of rocks and rock flowage, Van Hise, 75.

GEOLOGY—
Moraines of Minnesota, revision of, Todd, 469.
Niagara Falls, episode in the history of, Spencer, 439.
North American geology, Wales, 510.
Sauropodus Dinosauria, Marsh, 487.
Spines, origin of, Beecher, 1, 125, 249, 329.
Tertiary horizons, new marine, Ortmann, 478.
limestone reefs of Fiji, Agassiz, 165.
See also ROCKS.
Gillespie, D. H. M., iodine in the analysis of alkalies, etc., 455.
Girty, G. H., fauna from Devonian black shale of Kentucky, 384.
Glass, colloidal, Barus, 270.
Gooch, F. A., iodometric determination of molybdenum, 168; manganese as pyrophosphate, 233.
Gravitation constant and mean density of the earth, 503.

H

Hall, James, obituary, 284, 437.
Hall effect in an electrolyte, 504.
Harper's Scientific Memoirs, 199, 504.
Havens, F. S., separation of aluminum, by hydrochloric acid, 45; separation of nickel and cobalt by hydrochloric acid, 396.
Hay, O. P., species of ichthyodectes, 225.
Hidden, W. E., sperrylite in North Carolina, 381; twinned crystals of zircon, 323; associated minerals of rhodolite, 463.
Hill, R. T., geological history of Panama and Costa Rica, 435, 505.
Hillebrand, W. F., vanadium and molybdenum in rocks, 209.
Hintze, C., Mineralogy, 435.
Hoffmann, G. C., Baddeckite, 274; Canadian minerals, 437.
Holden, E. S., Earthquakes of the Pacific Coast, 200.
Howe, E., detection of sulphides, etc., 317.
Hutchins, C. C., irregular reflection, 373.

I

Isham, G. S., registering solar radiometer, 160.

J

Jamaica, late formations and changes of level, Spencer, 270.
Judith Mts., Montana, geology of, Weed and Pirsson, 508.

K

Keith, A., dikes of felsophyre and basalt in Virginia, 305.
Keyes, C. R., eolian origin of loess, 299.
Kreider, D. A., structural and magneto-optic rotation, 416.

L

Labrador Peninsula, traverse of, Low, 510.
Lacroix, A., granite of the Pyrenees, 511.
Lambert, P. A., Differential and Integral Calculus, 513.
Light, absorption in a magnetic field, Righi, 433.
Low, A. P., traverse of Labrador Peninsula, 510.
Lucas, F. A., contributions to paleontology, 399.

M

Marsh, O. C., Ceratopsia, 92; vertebrate fossils for the National Museum, 101; Jurassic formation on the Atlantic coast, 105; cycad horizons in the Rocky Mountain region, 197; value of type specimens, 401; origin of mammals, 406; fossils in determining Geological age, 483; families of Sauropodus Dinosauria, 487.
Martin, G. C., dunite in Western Massachusetts, 244.
Mineralogy, Hintze, 435.
Text Book, Dana, 275.
MINERALS—
Autunite, 42.
Baddeckite, 274.
Copper, native, Franklin Furnace, N. J., 187. Corundum, origin of, in North Carolina, 49.
Diaphorite, Washington and Mexico, 316.
Erionite, 66.
Kalgoorlite, West Australia, 199.
Kentrolite, New Mexico, 116.
Lead, native, Franklin Furnace, N. J., 187.

MINERALS—
Melanotekite, New Mexico, 116.
Miersite, New South Wales, 199.
Phenacite, pseudomorphs after, 119.
Rhodolite, associated minerals of, 463. Roeblingite, Franklin Furnace, N. J., 187.
Smithsonite, cobaltiferous, 123. Sperrylite, North Carolina, 381. Sulphohalite, 511.
Tantalite, crystallized, 123. Tapiolite, crystallized, 121. Topaz, supposed pseudomorphs, 121. Torbernite, etching figures, 41.
Zircon, twinned crystals, 323.
Mines and Mining in the United States, Law of, Barringer and Adams, 436.
Mixter, W. G., electrosynthesis, 217.
Moore, J. E., electrical discharge and the kinetic theory of matter, 21.

N

Niagara Falls, geology of, Spencer, 439.
Nipher, F. E., Electricity and Magnetism, 432.
North American geology, etc., Wales, 510.
Norton, J. T., Jr., iodometric determination of molybdenum, 168.
Nova Scotia, geology of southwest, Bailey, 510.

O

OBITUARY—
Hall, James, 284, 437.
Ortmann, A. E., new marine Tertiary horizons near Punta Arenas, Chile, 478.
Osmotic pressure, Traube, 194.
Ostwald's Klassiker der Exacten Wissenschaften, 200.

P

Packard, A. S., Text-book of Entomology, 103.
Paleontology, contributions to, Lucas, 399.
Palmer, A. deF., Jr., apparatus for measuring very high pressures, 451.
Panama and Costa Rica, geology of, Hill, 435, 505.
Penfield, S. L., Brush's Mineralogy, revised, 436.
Penniman, T. D., New method of measurement of self-inductance, 97.
Perry, physical geography of Worcester, Mass., 435.
Petroleum in Burma, Noetling, 102.
Physics, Elementary, Aldous, 100.
Pirsson, L. V., geology of Judith Mts., Montana, 508.
Pratt, J. H., origin of corundum in North Carolina, 49; twinned crystals of zircon, 323; associated minerals of rhodolite, 463.
Pressures, apparatus for measuring very high, Palmer, 451.
Pyrenees, granite of, Lacroix, 511.

R

Radiometer, registering solar, Isham, 160.
Reflection, irregular, Hutchins, 373.
Rhode Island, brachiopod fauna, Walcott, 327.
Richards, T. W., transition temperature of sodic sulphate, 201.
Richter, E., Seestudien, 103.
ROCKS—
Basalt in Virginia, Darton and Keith, 305.
Biotite-tinguaite, Essex Co., Mass., Eakle, 489.
Dunite, West Massachusetts, 244.
Felsophyre in Virginia, Darton and Keith, 305.
Granite of the Pyrenees, Lacroix, 511.
Igneous, composition of, Walker, 410.
of Christiania, Brögger, 273.
of Tasmania, Twelvetrees and Petterd, 511.
Laurdalite, Brögger, 273.
Lava flows of the Sierra Nevada, Ransome, 509.
Metamorphism of, Van Hise, 75.
Peridotite, occurrence of corundum with, Pratt, 49.
Sölvsbergite, Essex Co., Mass., Washington, 176.
Tinguaite, Essex Co., Mass., Washington, 176; Eakle, 489.
Vanadium and molybdenum in rocks, Hillebrand, 209.
Rotation, structural and magneto-optic, Wright and Kreider, 416.
Rowland, H. A., methods for the measurement of self-inductance, etc., 97.

S

Scientific Periodicals, Catalogue, 1665–1895, Bolton, 513.
Scripture, E. W., Yale Psychological Laboratory Studies, 512.

Seestudien, Richter, 103.
Self-inductance, new methods of measurement, Rowland and Penniman, 97.
Sierra Nevada, lava flows of, Ransome, 509.
Spencer, J. W., changes of level in Jamaica, 270; high plateaus and submarine Antillean Valleys, 272; episode in the history of Niagara Falls, 439.
Spencer, L. J., diaphorite from Washington and Mexico, 316.
Spines, origin of, Beecher, 1, 125, 249, 329.
Storage Battery, Treadwell, 101.

T

Tasmania, igneous rocks, Twelvetrees and Petterd, 511.
Todd, J. E., revision of the moraines of Minnesota, 469.
Treadwell, A., Storage battery, 101.
Type specimens, value of, Marsh, 401.

U

United States Geological Survey, 102, 433, 508, 509.

V

Van Hise, C. R., metamorphism of rocks and rock flowage, 75.
Verrill, A. E., new American Actinians, 493.

W

Walcott, C. D., Brachiopod fauna of Rhode Island, 327; fossil Medusæ, 509.
Walker, C. F., iodine in the analysis of alkalies, etc., 455.
Walker, T. L., crystalline symmetry of torbernite, 41; composition of igneous rocks, 410.
Warren, C. H., Mineralogical notes, 116.
Washington, H. S., sölvsbergite and tinguaite, Essex Co., Mass., 176.
Weed, W. H., geology of Judith Mts., Montana, 508.
Wells, H. L., Qualitative Chemical Analysis, 269.
Wells, J. S. C., Inorganic Qualitative Analysis, 269.
Wilcox, E. M., winter conditions of reserve food substances of certain deciduous trees, 69.
Wright, A. W., structural and magneto-optic rotation, 416.

Y

Yale Psychological Laboratory, studies from, Scripture, 512.

Z

Zeeman effect, Ames, Earhart and Reese, 99.
Zoology—
Actinians, new American, Verrill, 493.
Bibliotheca Zoologica II, Taschenberg, 103.

DO YOU WISH to be brought into direct touch with the Ablest Writers and the Ripest Thinkers? If so then to you THE LIVING AGE is a necessity. It presents, as no other magazine does, the world's movement along every line. No sphere of thought or action is left untouched, but the reader is kept informed on all subjects that move the mind or stir the imagination.

It reproduces the latest utterances of the highest **British** and **Continental** authorities, **French, German, Spanish, Italian, Russian,** etc., upon questions of international politics, and the freshest contributions in every field of literature, **Science, Investigation, Travel, Discovery, History, Art** and **Biography;** and prints in every number **Short** and Serial Stories of high excellence.

A COMPLETE COMPENDIUM OF CONTEMPORARY LITERATURE AND THOUGHT.

FORMING FOUR LARGE VOLUMES annually, aggregating about 3500 double-column, octavo pages. It alone, among current magazines, has the space to present with **Completeness and Freshness** all that is of immediate interest, or of solid, permanent value in **Foreign Periodical Literature.**

PRACTICAL AND POPULAR, it appeals to all alert and intelligent readers.

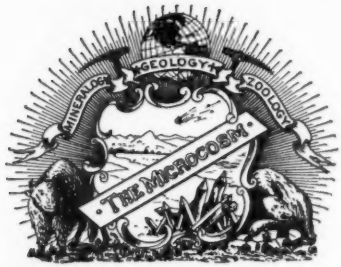
OBSERVE! **The Living Age** is a Weekly Magazine giving **Three and a Half Thousand** double-column octavo pages of reading matter yearly, forming four large volumes; representing a mass of matter **Unequalled in Quality and Quantity** by any other publication in the country.

Published Weekly at $6.00 a year, postpaid. Sample Copy 10c.

FREE **FOR THE REMAINDER OF THE YEAR.** To all **New Subscribers** for the year 1899, remitting before Jan. 1st, the weekly numbers of 1898, *issued after receipt of their subscriptions*, will be sent **Free.**

CHOICEST **LITERATURE AT CLUB PRICES.** For $9.00 THE LIVING AGE and any $4.00 monthly Magazine, (or *Harper's Weekly* or *Bazar*), sent for a year, or for $8.00 THE LIVING AGE and any $3.00 Magazine.

THE LIVING AGE CO., P. O. BOX 5206, BOSTON, MASS.



SYSTEMATIC COLLECTIONS

For teaching MINERALOGY, GEOLOGY and ZOOLOGY a specialty. Single specimens also furnished.

RELIEF MAPS AND MODELS.

The one establishment in America where correct and artistic work in this line is done. Send for list of 48 Relief Maps for Schools and Colleges.

LANTERN SLIDES, CHARTS, ETC.

METEORITES.

A good price paid for all kinds. Have the best machinery for cutting and polishing. Have now on hand for sale about FOUR TONS OF METEORITES from 40 cents to $200 per lb. Among them are Cañon Diablo complete, 40 cents to $1.00 per pound. Polished and etched sections ¼ to 5 cents per gram.

	Per Gram.		Per Gram.
Toluca,	3 to 5 cents.	Cross Roads (5),	$3.00
El Capitan (1),	10 to 20 "	New Concord,	5 to 10 cents.
Cherokee (1),	20 to 40 "	Winnebago,	8 to 15 "
Kendall Co.,	10 to 15 "	Beaver Creek (6),	20 to 25 "
Rockwood (2),	5 to 8 "	Kessen,	15 "
Doña Inez (3),	10 to 15 "	Pultusk,	13 to 15 "
Llano del Inca (3),	8 to 12 "	Mt. Joy (7)	8 to 12 "
Fayette Co (4),	3 to 8 "		

(1) Described in this Journal Sept., 1895. (2) Ibid Nov., 1887. (3) Proc. Roch. Acad. Sci., Vol. I. (4) This Journal Aug., 1888. (5) Ibid July, 1893. (6) Ibid June, 1894. (7) Ibid Nov., 1892

EDWIN E. HOWELL, 612 17th St., N. W., Washington, D. C.

ROY HOPPING,

5 and 7 Dey Street, near Broadway,

NEW YORK CITY.

MINERALS FOR SCIENTIFIC and EDUCATIONAL PURPOSES

MINERALS FROM THE AUSTRIAN ALPS.

A case from a small valley in Alpine district of Austria containing:

Perleline (Albite) in snow-white groups of large sharp crystals, some twinned; cabinet and small shelf specimens, 75c. to $5.00.

Penninite (Klämmerite), in groups of crested vermicular crystals, sharp bright faces, stout, over ¼ of an inch, associated with reticulated rutile. Small and large cabinet sizes, 75c. to $4.50.

Octahedrite (Anatase), the typical little acute striated octahedrons on mica schist and gneiss, brilliant black, at very reasonable prices, small to large cabinet specimens, 50c. to $3.50.

Fluorite (Fluor Spar), an entirely new variety, light to dark purple-black in large crystals, showy groups, none small, large cabinet and shelf specimens, 75c. to $2.50.

Adularia, a few groups of the typical sharp twinned crystals, neat cabinet size, 50c., 75c., $1.00.

New Illustrated Catalogue, 1899, bound in heavy boards, 10 full-page photo-engraved plates, and numerous cuts of crystal figures, etc., complete price list, interesting extracts and description of new arrivals, 25c. postpaid. Circulars of school collections, etc., free.

COLLECTIONS OF THIN-SECTIONS FOR PRACTICAL MICROSCOPIC-PETROGRAPHICAL STUDY.

I. New collections of well-mounted thin-sections of rock-forming minerals, containing the most important rock-forming minerals, arranged according to

H. Rosenbusch: Microskopische Physiographie der Mineralien.

3rd Edition, Stuttgart, 1897.

120 thin-sections of 67 different minerals in elegant case, ... $45.00
50 " 34 " " 17.50

II. Collections of thin-sections of rocks containing all important types of rocks as mentioned by

H. Rosenbusch: Microsk. Physiographie der Gesteine.

3rd Edition, Stuttgart, 1896.

To each one of them will be added a brief printed description of all the specimens and sections (by Prof. Dr. K. Busz, Münster, Germ.) in order that the student himself may be able to recognize and determine the constituents of the rocks. Three such collections will be provided.

1. *Collection of* 120 *thin-sections in elegant case,* $38.00
   Together with the 120 specimens—size 8½ x 11cm, ... 63.00
2. *Collection of* 180 *thin-sections in elegant case,* 56.00
   Together with the 180 specimens—size 8½ x 11cm, ... 98.00
3. *Collection of* 250 *thin-sections in elegant case,* 81.00
   Together with the 250 specimens—size 8½ x 11cm, ... 144.00

III. Collection of rock-forming minerals arranged according to

F. Zirkel: Lehrbuch der Petrographie.

2nd Edition, Leipzig, 1893–94.

In connection with these we provide the collections of thin-sections of rock-forming minerals to demonstrate the mode of occurrence of the minerals of the above named collection in the rocks,

130 Minerals, size 7x9 cm., ... $37.50
115 Thin-sections of minerals in elegant case, ... 32.50

THE NEW CATALOGUE OF MINERALS,

containing also list of mineral collections, collections of thin-sections of minerals, etc., and of meteorites, has just been published and will be sent post free on application.

ROCKS OF THE ODENWALD.

Complete collection of the most interesting rocks of the Odenwald Mts. in Germany, including all dike rocks (*Orbite, Luciite, Malchite, Beerbachite,* etc.) mentioned in the new Microscopic Physiography of Rocks by H. Rosenbusch, arranged by Professor D. C. Chelius, of Darmstadt.

Collection of 100 *thin-sections in elegant case,* $30.00
Together with the 100 specimens—size. 8½ x 11cm, ... 50.00

N. B.—All thin sections will be microscopically examined before being delivered. We can therefore guarantee their perfect reliability and that they exhibit all the characters and phenomena mentioned in the above named descriptions.

NOVELTIES. Klinozoisite, Fuggerite, Nat. Humus acid; from Greenland: Parisite, Catapleiite isolated crystals, Neptunite, Epididymite, Elpidite, Steenstrupine, Rinkite, Ænigmatite, Natron-Berzeliite, Pyroaurite; from Sweden: Edingtonite-crystals; from France: Gonnardite, Chalcomorphite. **Minerals and Fossils for single specimens or in collections, bought or exchanged.**

New editions of the following lists have come out and will be sent on demand:
Supplements 1 and 2 to Catalogue IV; New Rocks.
Catalogue V*: Professor Groth's collection of 396 crystal-models in wood.
Catalogue VIII*: Prof. Hintze's student collection of 150 crystal-models in wood.
Catalogue XI: Prof. Vrba's Collection of 280 crystal-models in paste-board.
Catalogue XII: Professor Baumhauer's collection of 102 crystal-models in plate-glass.
List of new acquisitions of excellent fossils.

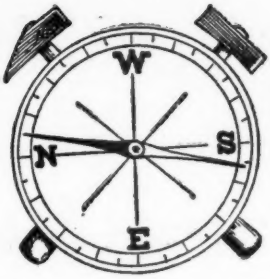
DR. F. KRANTZ,

RHENISH MINERAL OFFICE,

BONN ON THE RHINE, GERMANY.

ESTABLISHED 1833.

Represented in the United States by Messrs. Eimer & Amend. 205-211 Third Avenue, New York, who import above at 10 per cent. commission.



ARAGONITE.

Var. **Flos Ferri,** from Styria.

A few choice specimens of this peculiar snow-white coralloidal variety. Specimens range in price from.....$0.40 to $10.00

Also have several specimens of the interesting haloids—Bromyrite, Iodobromite, Embolite and Iodyrite. Prices from .25 to 5.00

AMETHYST.

We have recently added to our stock a fine lot of **Amethyst** from Hungary and Mexico. Many of the Mexican ones are partly covered with beautiful crystals of **Calcite.** Prices..... $0.50 to $8.00

FERRUGINOUS QUARTZ.

Several fine specimens of this variety showing doubly-terminated crystals. Sundwig, Westphalia. Prices..... $0.25 to $4.00

Hanksite. Good crystals from California ..... $0.50 to $3.00

Pisolitic Limonite, Australia. Polished section showing concretionary structure. Prices range from..... $0.50 to $10.00

Phosgenite, Sardinia. Well crystallized specimens ..... $4.00 to $25.00

Purple and Green **Calc Sinter,** Saxony. Very showy specimens. $0.50 to $3.00

We have in a European shipment **Chalcedony** from India showing an unusually large botryoidal structure; **Tourmaline,** var. **Schrool,** from Cornwall, and **Calcite,** from Cumberland, England. Also **Ruin Marble** from Italy.

STRUCTURAL and PHENOMENAL GEOLOGY.

We have just received a fine lot of **Stylolites** from Missouri and New York. Many of them are coated with Calcite which occurs as a secondary deposit. Prices..... $0.25 to $3.00

VEINS.

Hematite veins in **Quartz,** from Lake Superior. Large polished sections showing **faults.**..... $5.00 to $12.00

Quartz veins in **Tourmaline Rock,** Colorado..... $0.50 to $2.00

Trap veins in **Granite,** Norway, Maine; showing sharp contact lines. $2.00 to $20.00

SYSTEMATIC COLLECTIONS.

We wish to call special attention to our **Systematic Collections** representing *Tarr's Elementary Geology,* and Prof. E. S. Dana's latest work on *Minerals and How to Study Them.* Also our regular collections based on Prof. J. D. Dana's Mineralogy.

Information regarding these collections we will be pleased to furnish on application.

CATALOGUES.

Minerals, 168 pages..... $0.20
College Collection of Minerals, 44 pages ..... .10
Normal School Collection of Minerals, 30 pages..... .10
Meteorites, 24 illustrations, 80 pages..... .20

WARD'S NATURAL SCIENCE ESTABLISHMENT,

28—40 COLLEGE AVE., ROCHESTER, N. Y.

Our 36-Page Fall Bulletin

Is up to date and informs you of all new mineral finds of any importance. Mailed free.

Ankerite, crystallized,	Hungary,	10c.–$2.50
Barite, over 1,000 fine groups,	"	20c.– 5.00
Ludwigite, a very rare mineral,	"	50c.– 2.00
Orpiment,	"	10c.– 2.50
Realgar, bright red color,	"	20c.– 2.00
Stibnite, splendid groups,	"	20c.– 3.00

Actinolite, best in the world,	Zillerthal,	10c.–60c.
Cyanite, finest blue color,	"	30c.–60c.
Fuchsite, rare green mica,	"	30c.–75c.
Garnets, loose, 10c.–60c.: in matrix,	"	20c.–$1.50
Talc, green, foliated masses,	"	10c.–50c.

Aluminite, Halle, Germany,	30c.–50c.
Amber, including insects, Baltic Sea,	50c.–$1.50
Epidote, Sulzbachthal, Tyrol,	50c– 2.50
Fluorite, from all localities,	10c.– 5.00
Garnets, Fort Wrangel, Alaska,	10c.– 3.00
Niccolite, Riechelsdorf,	15c.– 2.50
Sepiolite, Asia Minor,	50c.– 5.00

Tarnowitzite, a few extra fine specimens.

Endlichite and **Melanotekite**, from New Mexico, at extra low prices, as we have secured the cream of the whole output.

Scheelite and **Wolframite** from **Zinnwald** are much superior in quality to the same minerals of any other locality—and much cheaper!!!

Utah Minerals: Aurichalcite, Clinoclasite, Conichalcite, Erinite, Martite, Mixite, Olivenite (green, red, white), Scorodite, Topaz.

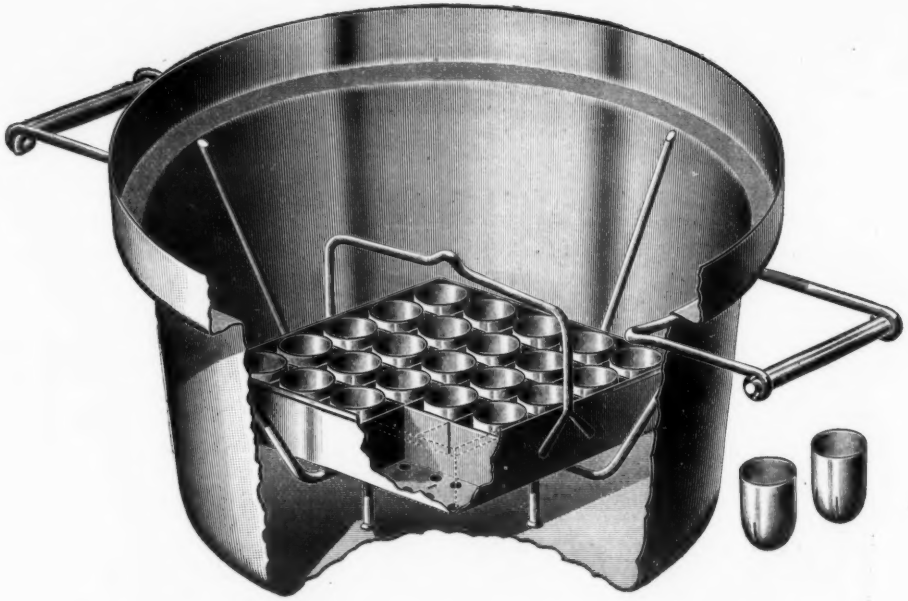
Cut opals and **tourmalines.**

Our strict rule is: Reasonable prices for good specimens.

IOWA MINERAL OFFICE,

DR. OTTO KUNZE,

IOWA CITY, IA.



Platinum Apparatus for the Parting of Gold and Silver made for U. S. Government by BAKER & CO., Mfrs. of Platinum Ware, Newark, N. J.

Send for Illustrated Catalogue, "Data Concerning Platinum." Fifth Edition.

REMOVAL SALE OF MINERALS.

During December, in anticipation of our removal in January to much larger quarters, we will make sweeping reductions in prices on spot cash sales as follows:

On minerals for blowpipe analysis, 33⅓ per cent.
On museum specimens, 33⅓ per cent.
On all other specimens, 25 per cent.
On gems, 10 per cent.

Extra Discounts:

On bills of $20.00 to $50.00, 5 per cent additional on net amount.
On bills of $50.00 to $200.00, 7½ per cent.
On bills of over $200.00, 10 per cent.

Select any Minerals you want from our great stock; here are a few suggestions:

MUSEUM SPECIMENS.

Splendid groups of **Galena** and **Sphalerite,** Joplin, $2.50 to $10.00; **Golden Calcites,** Joplin, 50c to $3.50. Superb groups of **Sulphur,** $5.00 to $7.50; Magnificent **Group Quartz,** Ark., $15.00; grand **Groups Calcite,** Stank Mine, $5 00; choice crystals of **Celestite** from Lake Erie, 50c. to $6 00; splendid groups of **Stilbite** from Iceland, $2 00 to $7.50; groups **Yellow Wulfenite,** N. M., $3.50 to $6.00; **Drusy Descloizite,** Arizona, $2.50 to $10.00; **Smoky Quartz,** groups, Maine, $3.50 to $10.00; **Crystallized Smithsonite,** N. M., $2.50 to $12.50; elegant group **Purple Fluorite,** England, $10.00; mammoth crystal **Selenite,** Utah, $15.00.

CABINET SPECIMENS.

Iceland **Stilbite** and **Heulandite,** 25c. to $2.00; **Dioptase,** $15.00 to $30.00; **Crystallized Hessite,** $3.50 to $6.00; **Broken Hill Cerussites,** $1.00 to $3.50; English Calcites, Fluorites, Barites, iridescent Dolomite, Hematite and Quartz; Swiss Smoky Quartz, "Iron Rose," pink octahedral Fluorite, Binnenthal minerals; Carpholite, Erythrite, Scheelite, Cassiterite, Lumachelle. "Satin Stone" Aragonite, sparkling Sunstone, flashy Labradorite, chatoyant Crocidolite, gorgeous Agates, splendid Chalcosiderite, polished Variscite and Wardite, crystallized Orpiment, Ark. Quartz crystals and groups. Quartz crystals with Chloritic phantoms. Look over our Bulletins and advertisements for many other desirable Minerals.

LOOSE CRYSTALS.

Magnetite, Boracite, Hauerite, Cobaltite, Pyrite, Microlite; Wulfenite, Vesuvianite, Zircon, Mellite, Apophyllite; Beryl, Calcite, Quartz twins, Dolomite (Ternelite), Phenacite: Sulphur, Aragonite, Beryllonite, Andalusite (Chiastolite), Barite; Borax, Scolecite, Selenite, Orthoclase, Tyrolese Epidote, Sphene, Azurite; Anorthite, Axinite, Amazonstone.

THIS IS A RARE OPPORTUNITY

to secure fine minerals at very low prices.

GEO. L. ENGLISH & CO., Mineralogists,
64 East 12th St., New York City.

CONTENTS.

Page

ART. XLIV.—Another Episode in the History of Niagara Falls; by J. W. SPENCER 439

XLV.—Apparatus for Measuring very High Pressures; by A. DEF. PALMER, Jr. 451

XLVI.—Application of Iodine in the Analysis of Alkalies and Acids; by C. F. WALKER and DAVID H. M. GILLESPIE 455

XLVII.—Associated Minerals of Rhodolite; by W. E. HIDDEN and J. H. PRATT 463

XLVIII.—Revision of the Moraines of Minnesota; by J. E. TODD 469

XLIX.—Preliminary Report on some new marine Tertiary horizons discovered by Mr. J. B. Hatcher near Punta Arenas, Magellanes, Chile; by A. E. ORTMANN 478

L.—Comparative Value of Different Kinds of Fossils in Determining Geological Age; by O. C. MARSH 483

LI.—Families of Sauropodus Dinosauria; by O. C. MARSH. 487

LII.—Biotite-tinguaite Dike from Manchester by the Sea, Essex County, Mass.; by A. S. EAKLE 489

LIII.—Descriptions of new American Actinians, with critical notes on other species, I.; by A. E. VERRILL 493

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics—Hyponitrous acid and Hyponitrites, KIRSCHNER: Experiments with Helium, TRAVERS, 499.—Calcium nitride, MOISSAN, 500.—Sodium sub-oxide and peroxide produced by combustion, FORCRAND: Aluminum nitride, FRANCK, 501.—Enantiomorphism, KIPPING and POPE, 502.—Doctrine of Energy; a Theory of Reality: Gravitation constant and mean density of the earth, F. RICHARZ and O. KRIGAR-MENZEL: Theory of the Coherer, E. ASCHKINASS, 503.—Theory of the Hall effect in an Electrolyte: Free Expansion of Gases, 504.

Geology and Mineralogy—Geological History of the Isthmus of Panama and Portions of Costa Rica, R. T. HILL, 505.—Geology and Mineral Resources of the Judith Mountains of Montana, W. H. WEED and L. V. PIRSSON, 508.—Fossil Medusæ, C. D. WALCOTT: Cretaceous Foraminifera of New Jersey, R. M. BAGG, Jr.: Lava-flows of the western slope of the Sierra Nevada, Cal., F. L. RANSOME, 509.—Bibliography and Index of North American Geology, Paleontology, Petrology and Mineralogy for 1896, F. B. WEEKS: Report on the Geology of Southwest Nova Scotia, L. W. BAILEY: Report on a traverse of the northern part of the Labrador Peninsula from Richmond Gulf to Ungava Bay, A. P. LOW: Report on the Geology of the French River Sheet, R. BELL, 510.—Granite des Pyrénées et ses phenoménes de contact, A. LACROIX: Igneous Rocks of Tasmania, W. H. TWELVETREES and W. F. PETTERD: Sulphohalite, J. H. VAN'T HOFF and A. P. SAUNDERS, 511.

Miscellaneous Scientific Intelligence—National Academy of Sciences: Studies from the Yale Psychological Laboratory, E. W. SCRIPTURE, 512.—Report on the Survey of the Boundary Line between Alleghany and Garrett Counties, Md., L. A. BAUER: Catalogue of Scientific and Technical Periodicals, 1665–1895, H. C. BOLTON: Differential and Integral Calculus, P. A. LAMBERT, 513.

INDEX TO VOLUME VI, 514.